This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

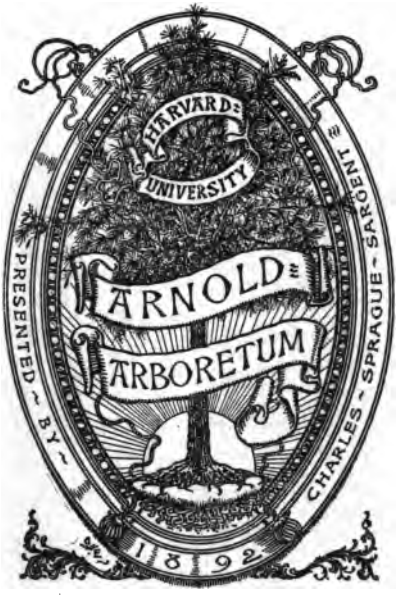
+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

T2
T93

JP



~~DEPOSITED AT THE HARVARD FOREST 1943~~

RETURNED TO J. P.
MARCH, 1967

TWO PRIZE ESSAYS

ON

The Adaptation of Land for Afforestation.

THE AWARDS FOR WHICH WERE GIVEN BY

The Worshipful Company of Carpenters.

No. 1. By Mr. A. C. FORBES.
" 2. " Professor W. R. FISHER.

LONDON:
PRINTED AND PUBLISHED FOR THE CARPENTERS' COMPANY
BY LAUGHTON & CO., Limited, 1, Essex Street, Strand, W.C.
1901.

[COPYRIGHT]

TWO PRIZE ESSAYS

ON

The Adaptation of Land for Afforestation.

THE AWARDS FOR WHICH WERE GIVEN BY . . . .

The Worshipful Company

. . of . .

Carpenters.

No. 1. By Mr. A. C. FORBES.

,, 2. ,, Professor W. R. FISHER.

LONDON:

PRINTED AND PUBLISHED FOR THE CARPENTERS' COMPANY

By LAUGHTON & Co., Limited, 1, Essex Street, Strand, W.C.

1904.

[COPYRIGHT.]

"Adaptation of land which has either gone out of "cultivation or which has only a very low rentable value "for afforestation: showing the mode of procedure from "taking the land over and for tweuty years after; and "some statistics as to what returns may be looked for "from this period up to maturity."

PART I.

GENERAL CONSIDERATIONS REGARDING THE UTILISATION OF LAND IN GREAT BRITAIN.

BUILDING LAND.

In order to clearly understand the economic aspect of timber-growing on the surface of Great Britain, it is necessary to briefly consider the principle methods by which land is now utilised. The greater part of the land in towns, and a small proportion of that in rural districts, is utilised as accommodation ground for the erection of buildings, and as highways for the travels of the inhabitants and the transit of their merchandise. For such purposes the value of the land varies with its situation, its height above sea level, and its suitability for the healthy existence and convenience of human beings, and their trades, occupations and pleasures. The more populous a district or area the greater the demand for land of this description becomes, and consequently the greater its value, which may vary from £1,000 or more per acre in a large town to £50 per acre in a village.

AGRICULTURAL LAND.

But the great bulk of the land surface of the country is used for quite another purpose, viz., that of growing crops as food for man and animals, and such land is commonly known as agricultural land. According to the Agricultural Returns it appears that about 48,000,000 acres of the total area of

Great Britain are used for agriculture in some shape or form, while an additional unreturned area exists in the form of small holdings of an acre or less in extent.

It is obvious that the great difference in determining the value of these two classes of ground lies in the fact that the value of the one depends upon its situation, and that of the other upon its productive capacity or soil fertility. For building purposes it matters little whether the soil consists of sand, gravel, loam, or clay, except so far as they affect the facilities for drainage and the water supply. But in any case the fertility of the surface soil is a mere detail which need only be taken into account at the time of its initial transference from the rural into the urban category. When once built over, the ordinary agricultural distinction between good, bad, or indifferent soil vanishes, and the one is practically as valuable as the other.

But in the case of agricultural land, the degree of natural fertility of surface soil is, other things being equal, in direct proportion to its value. This value finds its everyday expression in the term "rent," which may vary from £5 per acre in the case of exceptionally rich pasture ground, or land in the vicinity of large towns, to 2s. 6d. per acre on poor or elevated hillsides. A great deal of this rent is of course simply interest on capital expended in the original reclamation, fencing, and draining of the land, the erection of buildings, and the provision of roads, water supply, &c. But the difference which exists between the amount of this interest (if the true amount can be ascertained at the present day) and the actual rent obtained, has a more or less close relation to the natural surface fertility, which remains comparatively constant from one generation to another, unless abused or modified by human agency. An increase of population, for instance, may convert a naturally poor and low-rented soil into a more valuable one, not merely on account of the greater demand for it, but because the elements of artificial fertility in the shape of manure become more abundant and more easily applied. Depopulation, on the other hand, may exercise an influence in the other direction. But probably the greatest factor in altering the agricultural value of land within the last fifty years has been the reduction in the price of corn in general, and wheat in particular. The general effect of this reduction has been a relative appreciation in the value of pasture land, and a corresponding depreciation in that of arable, although this has been to some extent counteracted by a general depreciation of all agricultural land.

Naturally enough the alteration in the relative values of these rents has not been the only change with regard to the land producing them. Year after year for a considerable period, the Agricultural Returns have recorded a steady

decrease in the arable land of the country, and a corresponding increase in the area devoted to permanent pasture. A great deal of this latter was probably only returned to its original condition, for when wheat was selling at upwards of 60s. per quarter, a great deal of poor pasture land was broken up for that crop, which could not pay for cultivation when prices declined. But in addition to such land, thousands of acres have been laid down which had previously been cultivated from time immemorial, more especially on the lighter soils on the one hand and the heavy clays on the other. In the period from 1867 to 1871 Great Britain had 17,973,000 acres under arable cultivation, or 59 per cent. of the total agricultural area. In the period from 1897 to 1901 only 15,810,000 acres were under arable, or 49 per cent., a decrease of over 3,000,000 acres, or 10 per cent. on the total area. On soils with a certain amount of clay or alumina, time and manuring have, or no doubt will, convert these pastures into more or less good grazing grounds, but on sandy and open soils it is difficult, if not impossible, to render such land worth more than a few shillings per acre, and in dry summers they are practically worthless. Many of them have already reverted to their original condition, and are becoming overgrown by moss, heather, gorse, bracken, and other worthless vegetation, and although they may be enclosed, their agricultural value is little, if any, higher than the class of land it is now proposed to deal with.

Mountain and Heath Land.

Of the 48,000,000 acres of agricultural land given in the returns of the Board of Agriculture, 13,000,000 are returned as "Mountain and Heath land used for grazing," which is the official term for more or less waste land. Such land may vary from the fine turf of the chalk downs to a bleak moorland or high-lying mountain top or side. But it may be regarded as a fact that it consists almost exclusively of land which is in its unimproved and natural condition, and receives no treatment in the way of manuring, draining, or cultivation whatever. It is impossible of course to say how much of this land is capable of improvement or reclamation, and it is equally impossible to show what proportion is absolutely barren or worthless. Certainly large areas exist which would come under both categories, for it is impossible for the most careful surveys, or the most exact returns to indicate where one class of soil begins and the other ends, or to differentiate betwen the actual waste and the nominal pasture, and *vice versa.*

But it is apparent to every careful observer of our hill ranges and tracts of gravelly or sandy soils in all parts of Great Britain, that vast areas exist in a condition midway

between moderately good soil or rent yielding land, and absolutely barren rock, sand, or gravel. Steep banks, the sides of ravines and hills, marshy bottoms, and gravelly and sandy moors with a thin and scanty covering of grass, heath, or bracken, represent areas which might be termed practically waste so far as agriculture is concerned, and yet possess sufficient fertility to sustain plant growth if properly treated.

Causes of Heath or Waste Land.

The causes which are responsible for the existence of this heath or waste land may be summed up under three heads; first, elevation; second, open and porous nature of the surface; and third, waterlogged condition of the soil.

The effects of the first of these causes, elevation, are seen in the case of all high peaks and sloping hill-sides. Such land surfaces are undergoing what geologists term "denudation," that is, their finer particles are being washed down by rain, or blown away by wind to lower levels, where they are deposited in the plains, valleys, estuaries, etc., in the form of gravel, clay, or sand. The steeper the gradient the faster and more regular becomes the process of denudation, and the barrenness of such surfaces is due to the absence of soil, rather than to its poor quality. Whenever a certain gradient is reached, whatever soil may happen to exist is thin and and irregular in depth, and can only support the shallowest rooting plants, such as mosses or lichens.

The greater part of the agriculturally barren lands of Great Britain, however, are caused by the open and porous nature of the surface. In the case of hillsides, these surface conditions are found on the moderate gradients near the base or middle slopes of the hills. They are most common on hillsides which have a foundation of fissile or finely stratified rock. When such a rock weathers down, it tends to crumble to pieces irregularly, owing to some beds being softer than others, and upon their weathering more rapidly than those above them, the latter lose their support and fall down in the form of rock rubble or *débris*, which gradually accumulates at the base of the slopes. Such accumulations are naturally open and porous, and any fine soil particles which form on or below them from time to time are washed down to lower levels, leaving the surface either bare or covered with heather and plants of that kind, although, as will be seen later on, they are well adapted for tree growth.

Another class of such soils are the gravels and sands of the tertiary and other formations of a kindred nature. In the tertiary gravels, the barrenness is due to two causes, one of which is their open nature, and the other their being composed of little but quartz and hard stones, which weather too slowly to add to the fertility of the soil. In both sands and

gravels lime and potash are usually scarce, and insoluble silicates form the bulk of the surface soil. They are practically sieves through which all elements of plant food are washed as soon as they form. On these, heather is invariably the prevailing form of vegetation, often associated with Birch and Scots Fir.

Soils which owe their infertility to their water-logged condition are scarcer in Great Britain now than they were in past times. The universal drainage of the land, the embankment of rivers, and the general tendency to utilise the land to the utmost for agricultural purposes has reduced the area of such swamps to the lowest point, and it may be assumed that those now remaining are incapable of improvement without too great an expense being incurred. Still considerable tracts remain which are caused by the frequent overflowing of sluggish rivers, or by level beds of clay below a barren surface of gravel, which would be useless for agriculture if drained. The latter are often found on those recent formations already alluded to, and at high altitudes or in cold wet climates are the cause of peat bogs being gradually formed. Layers of iron pan are also frequently found where they occur, and this is often the cause of their sterility.

Distribution of Waste Land.

When one comes to inquire into the distribution of this semi-waste land in different parts of Great Britain, the result is what one would expect from the above-mentioned facts. The more elevated the land of various districts above the sea-level, and the more uneven its surface, the greater the proportion of waste land these districts contain. The more mountainous the district, and the greater the irregularities of surface, the greater the extent of denudation which goes on year after year, and it is therefore in the mountain chains which cross Great Britain from south-west to north-east that we find a preponderance of waste land. Of the 13,000,000 acres of mountain and hilly land returned as existing in Britain, no less than 10,500,000 lie in Scotland and Wales, while of the remaining 2,300,000 in England, the three northernmost counties of Northumberland, Cumberland, and Westmoreland are responsible for nearly 1,000,000 acres alone, whilst the single county of Yorkshire contains over half-a-million.

Considerable areas of waste land also exist in the southern counties. Hampshire has 88,000, Dorset 26,000, and Sussex 18,000 acres. The greater part of this area is occupied by the Tertiary gravels, Hastings sand, Greensand, etc., on all of which extensive heaths occur. In the eastern counties Norfolk and Suffolk have 75,000 acres of waste between them, chiefly covered by the Drift and Crag.

Coming more closely to details, it is found that the character of this heath or mountain pasture depends upon the geological formations upon which these mountain ranges are formed. Such formations as the Cambrian, Silurian, Mountain Limestone, Millstone, Grit, etc., together with the traps and granites of Cornwall and the Highlands of Scotland, form various surface soils in accordance with the mineral constituents, the rate of weathering, and the stratification of the rock of which they consist. Rocks which contain a large quantity of lime, such as the Chalk, Oolite, Mountain Limestone, etc., are usually more or less grass-covered, as in such cases the surface is generally more fertile and better adapted for holding moisture, and richer in the elements of plant food. Those, on the other hand, consisting chiefly of quartz, such as the coarser sandstones, Millstone, Grit, etc., are covered principally with heather and bracken, which are the only plants adapted for soils from which the more valuable bases have been washed out. Primary or igneous rocks usually form fertile soils when the latter have a chance to accumulate, but as they are often as quickly washed away as the rock weathers, such formations are usually barren at high altitudes.

The gravels and sands of the Tertiary, Drift, Crag, Greensand, Hastings Sand, etc., are all more or less barren if left to themselves, owing to their open nature, and the washed and water-worn materials of which they are formed.

The character of the rock which forms the backbone of the hill land is therefore of considerable importance to its agricultural value, for it is obvious that good soils cannot be produced from bad materials.

Agricultural Improvement of Heath Land.

The most gravelly surface or the most barren sand will yield to cultivation and manuring if labour and capital are forthcoming, but whether the expenditure will be justified by results is another matter. Some years ago the late Duke of Sutherland spent large sums in attempting to reclaim the heaths of Sutherlandshire, but the enterprise failed through the natural poverty of the soil. With ordinary farm or garden crops, experience proves that a profitable crop can only be grown on land which is naturally fertile enough in itself to produce at least half of an average crop without artificial manuring. Really good soils, properly cultivated, cleaned, and rested, will produce at least three-fourths of an average crop in a good season without manure, but the longer such a process is continued the smaller will be the yield, until a point is reached below which the natural fertility of the soil will not go. But before such a point is reached it is generally found that the costs of cultivation alone equal, if they do not

exceed, the value of the crop produced. The same principle holds good in the case of permanent pasture, although in this case cultivation may be eliminated, and the crop may be reaped in the form of grazing.

But whether the land be cultivated or grazed, its utilisation can only become profitable when the soil which produces the crop has a certain amount of fertility on the surface. All agricultural crops, whether cereals or pasture plants, are surface feeders, and must find their food in the first twelve inches of soil or so. If this food is lacking, the soil becomes barren for that particular crop, and however rich the subsoil may be in plant food its riches are lost, because out of the reach of the surface feeding roots, and cultivation and manuring can alone benefit such a soil agriculturally. In the case of heath land, it has already been shown that cultivation will not pay, and it may be assumed, therefore, that it is incapable of profitable improvement as far as agriculture is concerned.

Agricultural Importance of such Land.

The fact that a great deal of this heath land and mountain pasture is used for grazing purposes through the summer months may be looked upon as an objection to the term "waste" being applied to it, but when the reasons for turning it to account in this way are looked into it will probably be found that the term "grazing" is more or less a misnomer, and that "accommodation land" would be a more suitable term. It is a well-known fact that the occupation of land in all mountain districts is not confined to the fertile soils of the valleys or lowlands, but is extended to the adjoining waste, whether this be grass or heather. The reason for this is found in the fact that the former is too scarce to be used in the same way as land in the lowland districts, and that the utmost use must be made of it.

During the summer months every acre of productive land must be cropped to an extent which leaves very little room for the wasteful practice of summer grazing, and all the better class of pasture must be mown for hay. Sheep and store cattle are consequently turned on to the hills, where by running over a large area they are able to maintain themselves for three or four months in the year. But when the area of heathland necessary to support sheep or bullocks in this way is considered it is evident that the value of such land per acre is practically insignificant, and that the owner of the same simply gives his tenants the use of it as a bonus in order to raise the rent of the better land below. Its actual grazing value is not a twentieth part of that of good pasture in the valleys, and it is only a question as to the value of the land which is thus saved in the valleys by this method. What this is, of course,

cannot be stated offhand, but it is obvious that it varies according to the ratio one class bears to the other. Where the good land is extremely scarce the total value of the hill grazings is increased, for the greater the necessity of using the former for summer cropping. Such districts are often occupied by small farmers whose chief item is stock breeding and the keeping of store cattle through the summer. This they could not do if their holding consisted of good or high-rented land, for it is a well-known fact that the grazing of lean store cattle or sheep must be done cheaply to be profitable. The production of bone and muscle requires exercise, and this animals only take when compelled by hunger to range for their food, and this they would not do in rich pasture land.

To a certain extent, therefore, the possession of hill-grazing ground is a necessity unless a system of agriculture and a certain class of agriculturist are to be abolished, but while this may be so it does not follow that the retention of a large percentage of the total area of the country in a semi-waste condition is a necessity.

Allowing, however, that a certain proportion of hill grazing is a necessity, it is obvious that the force of this contention is strengthened in proportion to the grazing value of the land. Hill land which produces a fairly uniform growth of grass is certainly more valuable to the grazier during the summer than that covered by heath or bracken.

The best class of hill pasturage is probably found on the Chalk Downs, where the surface is fairly uniform and large stones are more or less absent. Next in order come those hill pastures resting on rocks in which lime still predominates, such as the Oolite, Mountain Limestone, etc. Such pastures of course vary with their elevation and the gradient of the hillsides, both of which influence the formation of soil and the quality of the pasture. But in any case their agricultural value is certainly greater than that of heath, bracken, and gorse-covered wastes on which grass is only a subordinate species. In the case of the latter the question may well be asked. Is their retention in a waste condition a necessity, taking the facts into consideration that their value to the grazier is practically nil, and that they occupy a large percentage of the land surface of the country?

Utilisation of such Land for Timber Production.

It is well worth considering whether the maintenance of this heath covered ground in its present condition is the most economical method of turning it to account, and whether the necessary quantity of hill grazing could not be provided on a smaller area and in a more economical manner. At the outset it may be at once stated that a few inches of loose soil or gravel resting on a foundation of solid rock is in that

condition which nature intended it to be, and no good purpose would be served by pretending to alter it. But as everyone acquainted with heathy waste is aware, a great deal of this land has more than a few inches of material above the bed rock, rock bottom, or whatever one may choose to call it. In one place may be found 12 inches, in another 18 inches, in a third 24 inches or more of loose gravel or soil which can be removed by the ordinary process of digging with spade, pick, and shovel. This material may consist of fairly fine soil and loose stones mixed indiscriminately together, which is its usual condition when it has fallen or been washed down from a higher level, or it may consist of fine material on the surface and coarser material below, which is more frequent on flat or gently undulating land. So far as the first 12 inches of this material is concerned it may be said to be more or less occupied by the roots of whatever surface growth happens to exist on it, and it is therefore put to some use from a biological point of view. But when such surface growth as heather, bracken, or coarse grass is the only form of vegetation present, it is obvious that whatever depth of soil or gravel may lie below this upper foot of soil is absolutely wasted. It may be the means of keeping the upper layer moist in dry weather by capillary attraction, and it may also be the medium through which superfluous moisture is carried off during heavy rain, but whatever fertility it possesses must be unutilised unless it happens to be washed out by spring and drainage water to other spots where the roots of plants are able to make use of it. It may be quite true that this non-utilisation of sub-soil is more or less general, and that it occurs on a much larger scale on areas of deep, rich soils devoted to agricultural crops but in the case of these it must be remembered that the value of the surface crop compensates in a great measure for the wasted or non-utilised material below, and this system of surface cultivation or cropping is justified. But it can only be justified in the case of the heath-covered ground under circumstances which render it impossible to grow a crop which is in a position to take the fullest possible advantage of the entire depth of soil, and the value of which crop would exceed that of the surface crop. Does such a crop exist? Very little consideration is needed before the conclusion is arrived at that trees fulfil the required conditions in this respect. In the first place they will grow on fairly deep soils and gravels where the surface is more or less barren, but which contain a certain amount of fertility in the subsoil. In the second place their value as a crop is infinitely greater than that of heather or other growths peculiar to barren surface soils. The annual value of heath or bracken covered soils cannot be estimated at more than 1s. to 2s. per acre on the average. The annual

net value of a crop of timber will vary with the soil and situation, but it may be estimated at from 5s. to 15s. per acre when grown on the class of land now under review, and providing the necessary conditions exist for its production.

PART II.

CONDITIONS NECESSARY FOR THE SUCCESSFUL AFFORESTATION OF WASTE OR POOR LAND.

The successful afforestation of land in Great Britain depends upon many factors, all of which are rarely present upon one piece of ground. In the absence of the more important of them, however, success cannot be attained on a large scale, for the larger the area dealt with, the more important is it to ensure those conditions which lead to a profitable growth of timber being obtained. Successful conditions may be roughly defined as those which bring about the production of an annual volume of marketable timber, the value of which exceeds the cost of producing it. However vigorous tree growth may be in one case, however valuable it may be per cubic foot in another, and however low the cost of production in a third, it is obvious that a profit cannot be obtained in any case unless these three factors bear a favourable relation to one another. A small yield must either be accompanied by a high price or low cost of production, while a high yield must not be counteracted or negatived by an excessively low price or high cost of production. When the two last-named factors remain constant, a profitable yield of timber depends upon the annual volume produced, and with a given soil and situation and given species, the profit per acre is directly proportionate to the rate of growth.

CONDITIONS OF GROWTH.

The chief factors in determining the annual growth of timber in Great Britain are much the same in the case of all species, although the presence or absence of the less important ones exert different influences upon different species. The most important are climate, situation and soil.

CLIMATE.

Upon the climate of the country depends the heat and moisture received from the sun and rain. Climate is affected partly by latitude and longitude, and partly by the distribution of land and water, and the prevalence of moist or dry, hot or

cold air currents. In Great Britain the effects of latitude and longitude are considerably modified by the warm and moist air currents caused by the Gulf Stream, which give these islands a more uniform temperature and moister atmosphere than would otherwise be the case. It also tends to reduce the difference between summer and winter, causing the summer to be cooler and the winter warmer, and the character of both seasons to be less pronounced than the continental type of climate peculiar to the same degrees of latitude. One result of this is to render the temperature of spring an uncertain mixture of summer and winter, while the actual temperature of a mid-winter's day may even prove identical with that of a day at mid-summer. The winters are usually alternations of warm and moist and dry and cold atmospheric conditions, and these changes become more rapid and frequent as spring approaches, and are even prolonged after vegetation has awakened from its dormant condition.

The average rainfall of Great Britain generally is about 30 inches, being rather higher in hilly districts and rather lower in a flat country. It is also higher on the West than on the East side of the country. Its chief difference from that of other countries is its more or less regular distribution over the whole year, and in this respect, and from the same cause, closely resembles the temperature. Except on dry soils and in dry summers, the rainfall is usually sufficient to satisfy the demands of most trees for moisture.

The most powerful wind currents which prevail in Great Britain are chiefly from the west, and may be said to play an important part in the success or failure of planting operations. The winds from the other points of the compass are comparatively harmless, but western gales are sometimes of sufficient force to sweep down whole acres of young plantations on thin soils, and practically destroy hitherto promising crops. They also affect height growth by breaking off the leading shoots from time to time, and trees exposed to this wind have shorter stems and flatter tops than those grown in more sheltered positions. When of moderate strength westerly winds are moister and warmer than those from the north and east, and are less injurious during the growing season.

The general effect of the uniform distribution of temperature and moisture throughout Great Britain is to render all parts of this island equally suitable for indigenous species, providing soil and situation are suitable. Practically as fine specimens may be seen in the north as in the south, although the greater rainfall during the summer months in the former acts prejudicially on the more heat and light demanding trees. But on the waste lands of the country and the class of trees best adapted for them, it is doubtful whether the south has any advantage over the north owing to the fact

that thin porous soils suffer less from and are benefited more by a wet climate than deeper and heavier ones. In addition to the native species, a large number of introductions, chiefly conifers, are eminently adapted for the climate and poorer soils of Great Britain. Species from the Arctic Circle on the north to the Mediterranean on the south, from the continent of North America, the mountain ranges of Asia, Africa, South America, and many trees from China and Japan can be grown side by side, and the growth of these species is almost as good as far north as Glasgow or Edinburgh as it is as far south as Devon and Cornwall. That a climate which renders such a marvellous collection of trees to be grown within nine degrees of latitude does not constitute an ideal one for all of them goes without saying. Species from a mean warmer climate are occasionally cut back or damaged by winter frosts, while those from a colder climate are often unduly excited into growth by spells of warm weather in early spring, only to be cut back by succeeding cold or night frosts. Species, again, which are indigenous to a country with a hot and dry summer atmssphere often make a too luxuriant growth, which affects the quality of their timber, and tends to the formation of badly lignified wood. In fact, the majority of introduced species have a local rather than a general value; and therefore the selection of the species for the locality is an important point in their cultivation.

SITUATION.

Situation may be dealt with under three heads: altitude or elevation, exposure, and aspect. Elevation above the sea level has both a general and local effect upon tree growth, and is more or less modified by exposure and aspect. The higher the elevation the lower becomes the temperature until a point is reached which is known as the snow line, above which vegetation of all kinds cease. The height of the snow line of course varies with the climate, being highest at the tropics and lowest at the Arctic Circle. Of the British mountain peaks, only a few, such as Snowdon, Ben Nevis, &c., are high enough to reach above the normal snow line of the climate, which lies at a height of about 3,000 feet; but for at least 1,000 feet below this, tree growth is either entirely absent, or assumes a form of spreading bushes, and it is only at a height of 1,500 to 2,000 feet, according to aspect, exposure, &c., that tree growth assumes its normal form. The more exposed the situation and the more northerly the aspect, the greater the effect of altitude. The summits of low hills near the coast are often less suitable for timber production than comparatively high elevations further inland, at which the exposure is modified by higher

ground and a southerly aspect. Further inland a fair growth may be expected up to 1,000 feet, after which a sheltered and southerly aspect are necessary for good results to be obtained.

Exposure may be defined as a state of comparative isolation from corresponding altitudes. Within certain limits the exposure becomes more severe the greater the distance of situation from equally high or higher land. The summit of a hill, for instance, rising rapidly 300 feet above a level plain at sea level is in all probability more exposed than the summit of a 600 feet elevation standing comparatively close to higher ground, or only slightly above the general level. On exposed situations air currents are always active, and their mechanical and physical effect is seen in the shorter annual growth, and possibly greater deviation of the stems from the perpendicular, than is the case in sheltered situations. The effect exposure exercises upon tree growth may be well illustrated by two examples. In the lake districts of Cumberland, the summits of what, in the lowlands, would be termed high hills are often clothed with well-grown trees. This is rendered possible by the existence of still higher hills in the immediate vicinity. On the seacoast again, at only a few feet above its level, all individual trees, or those on the margins of plantations, lean more or less away from the sea, whence the strongest winds come. Those on the outside of plantations are often low flat-topped trees, a few feet in height, while those behind them gradually develop into longer and straighter stems, the greater the shelter they receive from their neighbours to windward. Exposure, therefore, is a much more important factor in tree growth than elevation, and modifies the effect of the latter considerably. It has more influence upon the western side of Great Britain than the eastern, owing to the prevailing winds coming from the former direction. On the other hand, westerly winds are warmer and moister and not so injurious to active vegetation as the cold, drying winds from the east, which often prevail in the spring at a time when growth is at a critical stage.

The aspect is the inclination of sloping ground to different points of the compass. The more this inclination favours the heating of the ground, the more aspect modifies the effect of elevation, and the more it points away from the prevailing or injurious wind, the more it modifies the effect of exposure. In a hot, dry summer or climate northern aspects are cooler and moister than southern, and therefore more favourable to growth on dry soils, while in a wet, cold season or wet soil the reverse is the case. On the western coast, again, eastern aspects are more sheltered and better adapted for the production of straight-stemmed trees, while on the eastern coast western aspects are probably more favourable.

The general effect of situation, therefore, is to modify the influences of climate on the one hand, and soil on the other. The thinner the soil and the more extreme the climate, the more important situation becomes. Probably wind is the most important climatic feature of the British climate, and influences tree growth more than any other, prevailing as it does more or less throughout the growing season. Exposure becomes, therefore, an important element of the situation, and a certain amount of shelter is necessary to produce satisfactory results, the degree varying with the proximity of exposed coasts, the species grown, and to some extent on the depth and fertility of the soil.

Soil.

The soils of Great Britain vary to a considerable extent with the elevation and geological formation. The effects of elevation has already been explained in Part I., and reference was also made to the geological formation. The latter, however, can only be said to have a general effect on soils which have resulted entirely from the gradual process of weathering, or what are known as indigenous in sedentary. A soil, for instance, derived from chalk or limestone may be expected to contain a great deal of lime, that from sandstone an abundance of grit or silica, while a soil derived direct from granite, basalt, &c., is usually rich in all elements of plant food. The liability of various elements, such as lime, potash, phosphoric acid, &c., to enter into combinations which render them soluble in water has a tendency, as already explained to alter the character of the surface soil from that of the subsoil, the general result being that the surface soil, unless covered by thick vegetation or turf, becomes poorer as time goes on, and deficient in the various elements of plant food. It has also been pointed out that this impoverished condition of the surface soil is of less importance for deep-rooted plants, such as trees, than for agricultural crops, and as the former are able to take advantage of the subsoil, the derivation of the latter in the case of deep soils is of considerable importance. In the case of transported soils, again, consisting of material originally deposited in the mouths of rivers or at the bottoms of shallow seas, the underlying rock may even be of a totally different character, and unless it happens to come within a foot or two of the surface, can scarcely be said to affect the surface or subsoil at all. Such soils as these usually consist of clay, sand and gravel, and are of a more decided character than those in which these mechanical elements have been gradually formed on the surface and are mixed indiscriminately. Such transported soils as tertiary and recent clays, sands and gravels are therefore either stiff, retentive, and rich in the inorganic elements of plant food,

or are open, coarse and barren. They may, for all practical purposes, be said to consist of ordinary soils and subsoils in which the mechanical elements have been divided by the agency of water into three parts, the finest particles being represented by clay, the medium by sand, and the coarse by gravel. It often happens that beds of all three lie one above the other, and when an alteration of level occurs, one or the other is exposed on the surface as the case may be. Such soils, therefore, frequently vary in their composition, and any general estimate of their character by a superficial inspection of the surface or surface vegetation may lead to a considerable misconception of their true character or capabilities. For the growth of trees, suitability of soil varies with the species grown. For the majority of conifers and many of the shallow-rooted hardwoods, a very large proportion of the area occupied or covered by poor or thin surface soil is well adapted for their growth, and the conditions which render them suitable or the reverse may be gone into.

The three essential soil conditions for profitable tree growth on waste land are depth, moisture, and suitable chemical composition according to the species grown. For tree growth the ordinary agricultural distinction between soil and subsoil may be said to disappear. All loose material which contains plant food, and exists within three or four feet of the surface, is probably of equal value for tree growth, although aeration and the fertilising effect of rain may render the upper foot or so of greater consequence in strong or hard soils. But of two soils, the one comparatively deep but poor, and the other comparatively rich but shallow, it will usually be found that trees exist best in the former. Without depth trees cannot take that secure hold of soil which is necessary for their stability, and consequently on thin soils they no sooner reach a moderate height or size than they become liable to overthrowal by the wind. On shallow soils, again, root growth is restricted to the surface, and when the latter is fully occupied, plant food becomes scarce, and growth falls off where a thick crop of trees exist. Depth is therefore of the first importance, and it is necessary to consider where it is likely to be found.

On purely sedentary soils, depth will rarely be found at high elevations, unless on tablelands or plateaux, such as do not exist in Great Britain. But when levels are reached which approximate closely to the mean altitude of the country, the depth of soil and subsoil tends to increase, owing to the gradient more often falling within the angle of repose, or that angle at which the specific gravity of loose soil ceases to overcome its low cohesive power.

As a high hill is gradually ascended, it is usually found that the depth of soil or loose material decreases with the

altitude. This rule more often holds good the harder the rock and the more solid or homogeneous its character, owing to the fact that the distinction is sharp between the soil and the rock below, and the former is more easily washed away. It is a familiar fact that mud is more easily washed off a road in good condition and made of hard stone than one full of holes and made of soft materials. In the former case the rain which collects on the surface runs off uniformly and rapidly owing to the difficulty it finds in sinking into the road; in the latter case some of the mud collects in holes and hollows, and some remains in suspension in the rain water, and remains behind when the latter evaporates. Much the same process is followed in the case of denudation on the hill ranges. The harder the rock and the more uniform its surface, the easier the particles which result from weathering are washed off. As a rule, unstratified rocks have a smoother surface than those which are broken up into beds and possess a laminated structure which weathers irregularly, breaks up into fragments which are not easily washed off in themselves, and at the same time form crevices into which the finer particles are washed and held into position. The former often exhibit hard exposed rock surfaces and patches of fine rich soil without any intermediate stage, while the surface of the stratified rocks more often exhibits a comparatively regular depth of gravel or shattered rock, into which the finer particles resulting from weathering have been washed from above.

The difference in the value of two such rock conditions as those described above for tree growth are great. In the one case tree roots no sooner pass through the fine soil that may exist than they are met by a practically impervious matrix of solid rock into which they cannot penetrate; in the other they have a porous stratum into which they can readily find their way, and collect plant food in every crack and fissure. The value of the latter type of rock is often increased by the beds having a vertical inclination, thus enabling the roots to penetrate their joints more readily, and this hastens the process of weathering still more, while it increases the hold upon the soil that the roots possess.

Rock formations which answer to both the above descriptions are easily recognised. Granite, basalt, trap, syenite, or what are known as the igneous rocks represent the first-named, while the stratified rocks generally represent the second type. It is obvious that the latter are, in a general way, more valuable in proportion to the finely divided or stratified structures of the rock. A slaty structure, such as the Silurian, forms better material for tree growth than rocks composed of thicker beds, such as the carboniferous limestone, although the latter may form a better surface soil for ordinary

cultivation. Again, more or less vertical and crumpled strata, the basis of anticlinal ridges, which have been gradually flattened or hollowed out by denudation, usually form better surfaces for tree growth than horizontal strata, such as are often found on the middle oolite, lias, &c., which are only covered by a thin surface soil. In fact, the structure of the rock has a very different influence upon tree growth to what it has upon shallow rooting agricultural crops, and must be considered accordingly. The depth of the transported or younger deposits, which are chiefly represented by the tertiary sands and gravels, is invariably great enough to satisfy all demands made by tree growth, and as the soil and subsoil are practically the same, their depth need not be discussed.

In a general way a depth of at least two feet of porous gravel is necessary when the latter rests upon a hard rock surface. Where the rock is loose and crumbly a less depth of nominal soil is required, but eighteen inches should be the minimum if a good growth is to be insured. Depth, however, must usually be regarded in connection with moisture and chemical composition, as well as climate, rainfall, exposure, &c.

Moisture in a soil depends partly upon its power of retaining it and the amount it receives in the rainfall. Limestones are usually more retentive than sandstones, and sands more so than coarse gravels. In the North of England, Scotland, and the mountainous parts of Wales rainfall is usually sufficient to supply the moisture required for tree growth, especially such species as thrive on a dry soil, such as the Scots Pine, Beech, &c., and soil moisture due to its retentive properties is of less importance.

The chemical constituents of a soil, so far as tree growth is concerned, chiefly depends for its quality uponthe composition of the rock below, and for their quantity upon the rate of weathering and its physical and mechanical condition.

The quantity of plant food required by trees is, in proportion to their bulk, much smaller than that required by agricultural or garden crops. This may be partly explained by the fact that a prominent constituent of wood (carbon) is mainly derived from the atmosphere, and that the more valuable mineral salts are chiefly found in the leaves and fruit, which are again returned to the soil after a time. But another fact of probably equal importance is the power tree roots have of taking up their mineral food in solution practically throughout the year. Root action goes on more or less throughout the year, and the crude sap which is taken up and stored in the wood in autumn and spring is used during the period of active vegetation in summer. The period during which their plant food is collected is, therefore, longer

in the case of trees than with agricultural crops, and the exact quantity present in the soil at any one time of less consequence.

Species Suitable for Waste Land.

The suitability of waste land for the growth of timber trees depends entirely upon the species selected for planting and on the various grades of depth, moisture, and fertility which such land exhibits, as previously described. While some of it may, for timber growing purposes, be equally as valuable as the best agricultural land in the country, and able to grow such species as Oak or Ash, a good deal is only capable of supporting the most easily satisfied trees, such as Scots Fir or Birch. As regards depth or moisture, again, some species are more exacting than others and must be humoured accordingly. In fact, the utmost judgment and discrimination is needed in order that each species should occupy that particular soil and situation which will enable the greatest possible bulk of timber to be obtained from them.

The species usually grown, and most suitable for land varying from wet, peaty and swampy ground, and deep sand or gravelly loam at low elevations. to thin dry gravels at from 800 to 1,200 feet above sea level, may be enumerated as follows:—

Conifers, Scots Fir, Corsican Pine, Weymouth Pine, Austrian Pine, Larch, Spruce, Douglas Fir, Silver Fir, &c.

Broad-leaved species Oak, Ash, Beech, Sycamore, Birch, Poplar, Alder and Spanish Chestnut.

Taking the above species in the order named, an attempt will be made to describe the soil and situation on which each will give the best account of itself, and prove the most profitable tree under ordinary circumstances prevailing in this country.

Scots Pine.—This tree may be described as the last resource of the forest planter on poor soils. A soil which is too poor for Scots Pine may be usually regarded as hopeless, although trees may be found which will grow on thinner or shallower soils. For dry gravels of moderate depth, two feet and upwards, Scots Fir is undoubtedly the tree for producing the greatest bulk of timber up to an elevation of 800 feet or thereabouts, although it is often found higher. It is a fairly deep rooter, succeeds best when grown alone or mixed with a slower growing shade-bearer, and will stand any ordinary exposure with impunity. Although looked upon as a light demander, it will grow to a great age in close order, and without opening out its leaf canopy so much as many light demanders.

Corsican Pine.—The Corsican Pine chiefly differs from the Scots Pine in its rate of growth for the first twenty or

thirty years, being fully 50 per cent. faster, but little, if at all, superior in the long run so far as the volume per acre is concerned. But on fairly moist, fresh gravels, with an admixture of loam, marl, or clay, it produces much larger timber in a long rotation, the quality of which is equally as good as Scots Pine. It will also stand exposure well, and succeeds under the influence of the sea breeze better than most trees. Its one drawback is the difficulty often experienced in successfully transplanting it, unless the work be done in early autumn or late spring, which is not always possible in large planting operations. It should, however, never be moved in winter, if possible to avoid it, and on exposed sites in April only.

Weymouth Pine.—The Weymouth Pine succeeds better on deep warm sand and in sheltered situations than elsewhere, and should never be planted on cold soils or on exposed and gravelly hillocks. Its rate of growth is slightly faster than that of the Scots Pine, but the quality of the timber is superior for many purposes.

Austrian Pine.—This tree is of too coarse a nature to make good timber, and should be regarded as a species for planting on the margins of plantations or on exposed positions rather than a profitable timber producer. It requires fairly deep soil, but is not particular as to its quality.

Larch.—The Larch is the mainstay of all planting operations in which profit is the object in view in Great Britain. It not only grows rapidly on suitable soils, but is saleable from ten years of age or so, whereas other species can only be considered marketable at thirty years and upwards. The suitability of waste land for Larch, or the reverse, is therefore the strongest argument for or against planting it in cases where the planter wishes to obtain a return for his money personally. It is quite possible for land to be planted with Larch and cleared at a profit of from £1 to £5 per acre during the lifetime of an individual when soil, situation, and other circumstances are favourable. But in planting on a large scale Larch must not be relied upon too implicitly for forming the main crop, unless everything points to the probability of its proving a success. Its tendency to contract disease and to prove unsound at the heart renders it one of the most risky of all forest species to deal with, and while one plantation or part of a plantation may prove highly profitable, another will turn out a dead failure and produce material which hardly pays for cutting. The safest policy to pursue in connection with it, therefore, is that of treating it as a subordinate species until the critical stage is passed, and by mixing it with other and more trustworthy trees, secure the permanent character of the plantation in the event of the Larch giving out.

The soils best suited for Larch are fairly well represented on the hill ranges, which are occupied by so much of the waste land of the country. Probably the most favoured sites are the narrow glens and ravines which intersect and score the hillsides throughout their length and breadth, and which afford plenty of sun and air without too great an exposure to strong winds, while the soil is loose, porous and well moistened by the tricklings of water from above. In such spots Larch is almost sure to succeed, and may usually be planted almost or entirely pure at an elevation up to 1,000 feet, and allowed to develop its growth to the utmost.

Porous soils with a heavy and regular rainfall are as a rule also suitable for Larch, or those in drier districts which contain a certain amount of clay without being actually wet or retentive. Probably the worst kinds of soil are those very dry on the one hand and very stiff and wet on the other, although it is impossible to say with certainty where Larch will or will not succeed.

It may be laid down as a general rule, however, that Larch should never be planted pure where there is the least doubt about its success, unless the local demand is of such a nature as to render small Larch more profitable than large timber of any other species. Where large timber is the object in view it is always safer to mix Larch with such species as Corsican Pine, Beech, Spruce, Silver Fir, &c., which will either grow as fast as the Larch, or be able to survive after being slightly overtopped by it in the earlier stages. When so mixed the failure of the Larch at any time during the first forty or fifty years does not necessarily destroy the plantation as the other trees are able to take its place as the dominant species.

Spruce.—The average Spruce timber of Great Britain has such a bad reputation and is of such a rough nature, that many may possibly regard it as worthless and unprofitable. This, however, is not necessarily the case. In soils and situations little adapted for other species it is often possible to grow a heavy crop of Spruce which may be worth as much per cubic foot and have a greater volume per acre than many other species which are usually considered of more value.

The quality which renders Spruce of value under exceptional circumstances is its ability to grow on soils of the shallowest description, or on those which have a water-logged subsoil which is difficult or costly to drain. Moor and heath soils which have a subsoil of stiff clay or hard rock are often useless for the majority of timber trees of a deep rooting nature, but Spruce will often grow on them successfully, providing it has at least a foot of healthy soil to grow on. The position, however, must be fairly sheltered,

especially from sea air, and with a rock subsoil moisture must be fairly plentiful near the surface. In spots with abundance of atmospheric moisture, such as hollows, valleys, and the shaded air space of tall woods, Spruce usually succeeds whatever the soil may be. But when planted at high elevations in Great Britain, shelter and soil moisture are imperative. It must be planted in thick masses and thinned sparingly, and an unbroken front be maintained against the wind.

Douglas Fir.—The real value of this tree in British forestry has yet to be ascertained. Its wonderfully rapid growth and the undoubted quality of its timber have led many to regard it as the coming tree for plantations in this country, and facts certainly lend themselves to such an opinion. The Douglas Fir will grow on almost any soil except those containing lime, and on such it is useless to plant it. But on moist sand, fresh gravel, loamy and peaty soils of fair depth, and in sheltered situations it will probably prove a more rapid timber producer than any tree which can be grown. At high elevations, of course, it cannot compete with Larch or Scots Pine, as wind is fatal to a straight stem after a certain height has been reached, and it is also necessary to grow it in thick masses if clean timber is desired. It is rarely advisable to plant it at greater distances than twelve feet apart, with the intervals filled up with Spruce, Larch, Silver Fir, &c., which will check side growth in the early stages and enable planting to be done at a cheaper rate per acre.

Silver Fir.—In deep dry soils, but exposed positions the Silver Fir is a valuable species, although it is not one which can be turned to much account before the fiftieth year, and requires time to develop. It stands a westerly exposure better than most trees, and is invaluable for those exposed sites near the sea which require a deep rooting and hardy species. When young it is extremely sensitive to late spring frosts, and for that reason must not be planted in frosty hollows unless under the shade of light foliaged trees, such as Birch, Oak, Larch, &c. Compared with some conifers the timber of Silver Fir is not in great demand, and it is perhaps not advisable to plant it extensively, except where it serves a purpose in some other direction, as shelter, or for thickening up a wood of light demanders in a long rotation. At the age of 120 years it is stated to produce as much as 17,000 cubic feet per acre, and individual trees of 300 feet and upwards are not uncommon, while its height growth exceeds that of any European species.

Broad-leaved Species.

In a general way poor soils are not so well adapted for broad-leaved species as for conifers. With a few exceptions

the former require better and deeper ground and more sheltered positions than the majority of needle-leaved species, and they are seldom chosen for planting on a large scale. On all large areas, however, a few spots at the least will be found capable of growing Beech, Hornbeam or Sycamore, and possibly Oak and Ash, and when they do occur it is good policy to take advantage of them for several reasons. In the first place the price of Oak and Ash is at least double that of the average conifer price, and this renders a crop consisting partly of these species more valuable on the average. Secondly, a species such as Beech is of great service in shading the ground, furnishing a heavy leaf fall, and adding to the humus layer, and consequently to the fertility of the soil. An admixture of hardwoods again adds to the wind-resisting power of the plantation, for their deeper rooting power gives a stability to the crop generally which it lacks when entirely composed of shallow rooting species.

Oak.—The requirements of Oak are well known, and it is merely necessary to point out the most likely results of planting on the waste lands of the country. At high elevations or on dry thin soils this species does not succeed, and it is useless to plant it. But wherever depth and moisture are present there is a fair prospect of growing small-sized timber at low elevations, although such results as are attained on better classes of soils are not expected.

For Oak, depth and a certain finely-divided state of the soil is imperative. Deep sand, for instance, will often grow fairly good Oak, and a great deal of the area covered by alternations of gravel, sand, and clay in the South of England produces Oak of a size and quality which one would not expect from the character of the surface soil. Success is greatly favoured by, and often depends upon, a mixture of Beech. This latter tree not only improves the fertility of the soil, as already pointed out, but by confining the Oak to a single stem, compels a tall and straight growth in place of the crooked and stunted bole which usually results from comparatively poor soil. A mixture of Oak and Beech, therefore, will often succeed on soils of uniform depth, at elevations of less than 500 feet in the South of England, where Oak alone would not turn out a success. It is, however, by no means asserted that gravel and sands form ideal soils for this tree, as a great deal of the timber is often shaky, and it is only on the better class of them that it should be planted. But as both Oak and Beech are in general demand, while many conifers are more or less uncertain in that respect, it is certainly worth while to take advantage of the demand for the former as much as possible, and at least give them an opportunity of turning out useful timber.

On most soils of this description it is, however, advisable

to mix Larch or Spruce freely with the Oak and Beech. If the first named and Oak fail, the Spruce and Beech will form a crop which is better than nothing, and will probably pay expenses. The sessile flowered should always be planted in preference to the pedunculate variety on light soil.

Ash.—Ash demands more moisture and a greater amount of soil fertility than Oak, and given these it will grow at higher elevations than the latter. Except for small timber, however, it is useless to plant it in close mixed plantations, as more head room than can be economically given is necessary for the production of large timber. On the margins of small streams, where beds of good loam or silt often accumulate, and where moisture without stagnation is always plentiful, Ash often does well, and in such places it may be planted.

Beech.—From what has already been referred to in connection with other species, it is evident that this tree has a subsidiary as well as a primary importance. The term "nurse" is often applied to many coniferous species, but it is doubtful if a species can be found which fulfils the more or less imaginary duties pertaining to the office better than, if as well as, the Beech. It has a knack of drawing other species up with tall clean stems which delight the eye of the economic forester, and a crop of Oak, Larch, Scots Pine, &c., mixed freely with Beech usually produce a large percentage of first-class timber. On the better class of light and dry plantation land throughout the country, therefore, Beech should always be planted in moderate quantities as a mixture with most light-demanding species, both to aid them in making better shaped boles and to add to and preserve the soil fertility, moisture, &c. Whether Beech should be planted pure or not may be well questioned. The only districts in which pure Beech woods exist to any extent in Great Britain at present is that round the chairmaking industries of High Wycombe. These woods are more or less indigenous, and the chair industry owes its origin to their existence as much as anything, while the woods themselves owe their reproduction to a particularly favourable soil and conditions of growth which do not prevail in many districts. To plant pure Beech is therefore a doubtful experiment, which may well be left alone so long as quicker growing and equally profitable species can be grown.

Sycamore.—As a plantation tree the chief use of Sycamore is in forming shelter belts round the margins. It occupies the same place amongst hardwoods as Austrian Pine does among conifers, in its ability to stand the sea air and the rough winds of exposed spots in maritime districts. Its value as timber chiefly depends upon turnery and cabinet-making, and while fabulous prices have been paid in the past

for large butts, it cannot be said to have ever gained a great reputation as a profitable timber tree.

Birch.—The Birch is the usual companion of Scots Pine in high situations and thin soils, and is chiefly valuable in its ability to grow anywhere and in spots where nothing else will.

Black Italian Poplar is probably the quickest timber producer that exists amongst hardwoods, and for low swampy spots which cannot be properly drained, but which have plenty of depth, is as profitable a tree as can be grown. This tree and Spruce can often be grown together with advantage, as the head room required by the Poplar can be given by planting it about 20 feet apart, and the space between filled up with Spruce.

Alder is also a suitable species for such spots, but does not produce anything like the bulk of timber that Poplar does.

Spanish Chestnut.—For light deep soils and warm climates the Spanish Chestnut is one of the most profitable trees that can be grown, so long as it receives suitable treatment. From youth up to middle age its timber is little inferior to the Oak, while its rate of growth is nearly double as fast. The best soils for Spanish Chestnut are deep, warm, and dry sands and gravels in the South of England, and it may be grown either pure in the form of coppice wood or mixed with a fast-growing tree, such as Larch, Corsican Pine, Douglas Fir, &c. In the latter case it must be cut out in the thinnings before the fiftieth year, unless the entire crop is ripe by that time, which may be the case if it be mixed with Larch. If allowed to stand longer than 50 years, its timber becomes shaky and of little value, while its spiral habit of growth renders it badly adapted for splitting into posts or rails. When cut early or grown into poles in coppice, it forms valuable fencing materials, and yields a heavy bulk of wood per acre. Wet soils or cold, backward climates or districts are not suitable for it, and it should not be planted at high altitudes or in situations subject to late spring frosts.

SUITABLE ROTATIONS AND AVERAGE YIELDS PER ACRE AND PER ANNUM OF THE ABOVE SPECIES.

Conifers.

Species	Rotation	Yield	Average Price
Scots Pine	70—100	30— 60 feet	4d — 8d
Corsican Pine	70—100	40— 80	4d — 8d
Weymouth Pine	80—100	40— 70	6d — 10d
Larch	40— 80	40— 60	9d — 1/-
Spruce	60—100	40— 80	3d — 6d
Douglas Fir	50— 80	50—100	6d — 10d
Silver Fir	80—120	60— 80	4d — 8d

Hardwoods.

Oak	80—120	20— 40	1/- — 2/-
Ash	60— 80	30— 60	1/3— 2/6
Beech	70—100	40— 80	6d — 1/-
Birch and Alder	40— 60	20— 50	3d — 6d
Poplar	40— 60	50—100	4d — 8d
Spanish Chestnut	40— 60	40— 60	10d — 1/-

The lower rotations and smaller yields apply to the worst, and the larger and higher to the best situations. The mean figures may be taken as the general average for the class of soils now under discussion. The prices are based upon those prevailing at the present time, and it is not probable that they will ever be lower for first class timber, and there is a possibility of their being higher. Douglas Fir, for instance, has not yet been grown long enough to produce commercial timber of high quality, and the greater part of home-grown Spruce and Silver Fir is too coarse to fetch a proper price.

The Profitable Disposal of Timber.

It has already been remarked that the price per cubic foot obtained for timber must bear a favourable relation to the costs of production, and that the latter, as far as the unit or cubic foot is concerned, decreases in proportion to the number of cubic feet produced per acre. The minimum price which must be obtained per foot in order to cover the costs of production consequently depends upon the quantity produced, and must be higher in the case of a small than in the case of a large quantity, assuming the costs of production remain the same, which is not always the case. It is only possible to deal with this aspect of afforestation in a general way, as the price of timber not only varies with the different species and sizes, but also varies from year to year, and differently in different localities, and to grow timber on the strength of definite statements or estimates would therefore only lead to unanticipated and possibly disappointing results. The conditions which regulate the price of timber depend, first, upon the demand for it, and secondly, upon the cost of its carriage to a consuming centre. The demand for any given species of timber is regulated by the variety of uses to which it is put and by the existing relation between supply and demand. Apart from fancy woods, such as those used in cabinet-making, furniture, &c., the number of species used in ordinary industries on a large scale is comparatively small. Of species indigenous to Great Britain, those most generally used are Oak, Ash, Beech, Elm, and Scots Pine, while of naturalised species Larch is about the only one extensively used. It is not asserted that the six species above named are

the only ones worth growing, but it is asserted that they constitute three-fourths of the home-grown timber now used for which any serious demand exists. Many other species are asked for from time to time, but the uses to which they are put are either too few or on too small a scale, or else the supply is too limited for them to rank as important timber trees.

In the absence of a steady and general demand, the owner of mature timber is exposed to the risk of having to sell at below cost price in order to clear, or of having the timber deteriorate on his hands until a temporary demand for it occurs. In the one case profit is precluded; in the other it depends upon an accidental local rise in price which may be too late to turn a loss into profit. The general demand for any species is therefore an important factor in securing a minimum or adequate price for it, and must be considered a strong point in its favour.

The relations existing between the supply and demand probably determine the price of timber to a less extent than its general utility, and have a more or less temporary effect upon its value. Fluctuations occur in the price of all commodities, but the majority of them are within well defined limits. In the case of the timbers in general use throughout the country, fluctuations in value of more than 25 per cent. are very rare. Such fluctuations may arise from depression in trade in general, or in the particular industries using the timber, or from a larger quantity being placed on the market without regard being paid to the normal demand. Gales often bring about gluts in the timber market which depress prices for a month or two, and such are more common in the neighbourhood of coniferous woods in the north than amongst the hardwoods of the south. But they are often as much due to the anxiety of owners to get their timber cleared off the ground at once as to the aggregate quantity down at one time, although exceptionally severe gales may disorganise sales altogether for a year or two.

Cost of Carriage.

The distance at which timber stands or grows from a consuming centre is as important a factor in regulating its price as the general demand for it. This may not be the case, perhaps, in the case of very high-priced timber, which only exists in small quantities, and which must be obtained at any cost. But, as a general rule, it may be asserted that the cost of carriage from the wood to the sawmill, railway, or consuming centre is always allowed for in the price paid for timber in the wood, and that the further the latter lies from such central positions, and the fewer the facilities for carriage, the lower the price obtained for it. The cost of carriage by

road of a bulky article, such as timber, varies from ¼d. to 1d. per foot per mile, according to the total distance, nature and conditions of roads. The cheapest rate per mile is in the case of fairly long distances the dearest in the case of short distances, although the aggregate cost varies more or less generally with the distance. The reason for the difference of the mileage rate may be found in the following considerations: In a general way, the cost of timber haulage is reckoned by the journey, and not by the mile. In the case of a short distance of two to three miles, two journeys ought to be made by a team of three or four horses per diem, and the cost per foot per mile should not exceed ¼d. But above that distance, and up to eight or ten miles, only one journey can be made by horses at a cost of ⅓d. per mile per foot, and the difference between five and eight miles in the distance, although it may affect the wear and tear, does not make an appreciable difference in horse hire. The rate per mile is lower in the case of the longer journey, therefore, than it is with the shorter, although the total cost per foot remains the same.

In much the same way the rates per ton per mile for railway carriage are proportionately lower the longer the distance, as the cost of loading and unloading is the same for a short as for a long journey.

It follows, therefore, that the cost of carriage and the corresponding reduction in the price of timber in the wood do not bear any direct proportion to the exact distance from a consuming centre. After a certain distance separates the two localities the cost increases for all practical purposes, and remains stationary for a few miles, when another addition must be made to it, and so on until the total cost becomes prohibitive or exceeds the value of the timber. Generally a distance of eight to ten miles from the consuming centre, providing good roads exist, deducts about 3d. per foot from the value of the timber in the wood, while a distance of twenty miles may make a difference of 4d. to 5d. The larger the quantity sold or purchased, the smaller the difference between delivered and wood price should be, because large quantities favour economical handling. With a large quantity it is possible to cut up a good deal of the timber on the spot and save the carriage of waste and defective timber, while different specifications can be forwarded direct to their destination by the shortest route, instead of possibly having to traverse the same ground twice.

Facilities for Carriage.

In addition to the actual or general distance from a consuming centre, the value of the timber is also determined by the facilities which exist for its carriage. Good roads or

railways form the most convenient media by which timber can be moved, as they lead everywhere, but navigable rivers and canals may be largely taken advantage of. When either of these two run through or close to standing timber, its value ought to be increased, as water carriage is exceptionally cheap. As a general rule, however, they more often run through fertile and well cultivated districts than hilly or waste land, and roads and railways are the most common agencies by which timber is carried.

As the use of traction engines enables timber to be hauled much cheaper than can be done by horses, the existence of a good hard road is of the first importance to forest areas, and adds considerably to the value of the timber, and without them it is often difficult to get a remunerative price in the wood.

General Conclusions.

From the above facts it may be concluded that for the price of timber to be maintained at a profitable figure, first, it must consist of a species which is in general demand; second, be placed on the market in convenient quantities; third, must either grow within ten or twenty miles of a consuming centre or under favourable conditions for its carriage to them; and fourth, that the greater the cost of carriage, the larger should be the quantity grown, and the more wholesale the method of disposing of it.

Costs of Production.

The costs of production may be divided into two parts: (a) initial outlay preparatory to and including planting, and (b) yearly outlay, including cost of maintenance.

(a) *Initial Outlay.*—This includes, first, the value of the land; second, the cost of fencing; third, draining and soil cleaning; and fourth, planting.

The Value of the Land.—The agricultural value of waste or semi-waste land, which answers to the description given above, may vary from 1s. to 5s. per acre, and it is quite possible that its value for planting purposes may be inversely proportionate to its agricultural value. It would be quite reasonable, therefore, to put the average annual value of such land at 2s. 6d. per acre, and as it is a question of withdrawing it from agricultural purposes for practically a century or so at the least, the only practical method of acquiring it is by purchase. At 20 years' purchase this would amount to 50s. per acre.

The Cost of Fencing.

The cost of fencing is an extremely variable item of expenditure, and may range from 10s. to £10 per acre, according to the area and shape of the ground. The larger

the area and the more compact the shape, the smaller the cost per acre ought to be, and with a large area of from 500 to 1,000 acres, ought not to exceed £1 per acre, and may be even less. When ground is acquired by purchase, for instance, it is invariably found that part of the boundary line is already fenced, or occupied by fences upheld by adjoining owners, while another part may consist of natural boundaries, such as rivers, or such boundaries as roads along which fences are either not required, or only required in a cheap form. The law compels the owners of two adjoining properties to share the cost of a boundary fence between them where cattle have to be confined to their owner's ground, and it is unusual for the expense of much more than half the boundary fences to fall upon one owner. For the above reasons it is probable that the usual estimates of the cost of fencing plantation ground on a large scale are in excess of what would actually be required for a judiciously selected area, and that £1 per acre is a liberal allowance, with an additional 5s. when rabbit netting is required.

Draining and Cleaning the Ground.

This work, like fencing, varies considerably, not only with the ground but also with the species to be planted.

Draining is an item which may be carried to a ruinous extent, although it may still be advantageous, or even necessary, from a purely sylvicultural point of view. On a large area of comparatively poor ground, it is doubtful if a higher average expenditure per acre than 1s. to 2s. is justified by results, for mere soil moisture is not an evil when brought in contact with the species able to bear it, and this, rather than expensive draining, should be the aim of the forester.

Cleaning the ground is an item which is chiefly incurred on ground covered with thick turf, long heather, bracken, gorse, broom, brambles, and woody scrub of any kind. Turf may require breaking up, heather burning or cutting, and the other growth burning, cutting, or grubbing up, as the case may be.

On the whole, soil preparation of this kind may not incur a greater average expenditure than 1s. to 2s. per acre when the greater part of the area is covered with heather alone. Where large areas of gorse-covered ground exist, an expenditure of as much as 8s. to 12s. per acre may be necessary, but when the surface is level enough for steam cultivation, this may be reduced by half. On an average, however, the total cost per acre ought not to exceed the sums named above.

Cost of Planting.

The cost of planting may vary from 10s. to £6 per acre. On hillsides and heathy wastes slit-planting may be done for

£2 to £3 per acre, while on ground covered with rougher herbage pit-planting may run from £4 to £6, provided that ordinary forest trees are alone used. A general average of £4 per acre should be ample for all planting expenses on a large area, allowing for cartage, beating up, &c.

Cost of Maintenance.

The costs of maintenance consist in cleaning, thinning, and attending to the young crop up to the twelfth or fifteenth year, and supervision, rates and taxes throughout the rotation. In the first three or four years after planting, cleaning expenses may amount to 5s. per acre per annum, but after that little or nothing up to the first thinning. Spread over the whole rotation, the average annual cost is therefore small, as after the first thinning the work should pay for itself. Supervision depends upon the size of the area, and whether it is completely isolated or managed in connection with other areas. On an average it will amount to 1s. 6d. per acre on a large area. Rates and taxes at 8s. in the pound amount to about 1s. per acre.

The total cost of maintenance on a large and compact area may be put down at 3s. per acre, but would be higher on an area of less than 500 acres.

The Total Costs of Production.

The total costs of production per acre may be summed up as follows :—

	£	s.	d.
Purchase of land	2	10	0
Legal and other expenses ...	0	2	0
Fencing and netting	1	5	0
Draining and soil cleaning ...	0	3	0
Planting	4	0	0
Cost of maintenance capitalised at 2½ per cent.	6	0	0
	£14	0	0

The planting of land on the above estimate involves therefore, the sinking of a sum of £14 per acre until the end of the rotation, when it should be repaid with interest by the value of the crop. As a partial set-off to this outlay will be the net value of the thinnings from time to time, but these may be reserved to cover unforeseen expenditure, maintenance of fences, the formation of roads, &c.

The shorter the rotation, the smaller the amount to be repaid, and in all probability the smaller the value of the crop. An average rotation of fifty years may usually be considered the lowest that can be adopted when timber is the

object in view. Compound interest for that period at 2½ per cent. has, therefore, to be reckoned, and £14 would amount in that time in round numbers to £50. Deducting the £6 invested for annual maintenance leaves £44 as the sum to be repaid before a profit can be claimed.

Relation of Yield to Cost of Production.

By comparing the average yields given under "Suitable Species" with the estimated cost of production it is possible to see the financial aspect of timber growing in a general way.

With an average annual production of 40 feet per acre for conifers and an average price of 6d. per foot, the volume and value of a crop at fifty years should be 2,000 feet and £50 respectively. This would leave a balance of £6 per acre, equal to an annual rent of about 1s. 2d. per acre for the whole period. With the same costs and price per foot, but a yield of 50 feet per acre per annum, a balance of £18 would remain, or an annual rent of 3s. 6d. per acre. While the former of these two sums is less than the unimproved value of the land, the latter is about equal to it. An annual average production of 40 feet per acre with the quoted costs of production, therefore, can hardly be said to pay for the time and trouble involved unless a higher price per foot can be obtained than is assumed. With a price per foot of 9d. for instance, the total volume of 2,000 feet would be worth £75 and give an annual return of about 6s. per acre.

It must be pointed out, however, that calculations based on a fifty years' rotation give in most cases a lower annual return than would be the case with a rotation of seventy or eighty years, as in the latter the value of the crop would increase at a higher ratio than the accumulated cost of production, and it is seldom that a crop can be profitably cut at the former age unless it be Larch or Spanish Chestnut. But at fifty years of age most timber crops have reached or will shortly reach that stage at which their value equals the cost of producing them, and when the balance between these two amounts begins to turn in favour of the crop. It is, therefore, a convenient age for taking stock of the crop on the ground, and ascertaining the probability of its turning out profitably or the reverse. If still healthy and growing at the normal rate, a profit may be expected, but if neither height nor diameter growth are good it is often a question whether the ground should not be cleared and loss avoided.

Summary of Conclusions Arrived at Regarding the Planting of Waste Land.

The conclusions arrived at from the above statements so far may be summed up as follows :—

1st. *Class of Land Adapted for Planting and its Agricultural Value.*—The class of land best adapted for planting

is that which, owing to surface sterility, cannot be profitably, cultivated, and is not of paramount importance to the grazier, but which has a sufficiently deep subsoil to produce a crop of timber of greater net value per annum than the rent derived from grazing. The annual agricultural value of such land does not average more than 2s. 6d. per acre.

2nd. *Situation and Soil.*—The situation of suitable land does not lie at greater altitudes than 1,000 to 1,200 feet above sea level, and is not exposed to winds direct off the sea. It lies within 10 to 20 miles of a consuming centre, or inthe immediate neighbourhood of good roads, railways, canals,&c.

The soil and subsoil have a minimum depth of 18 to 24 inches of sand, gravel, loam, or loose rock, free from stagnant moisture, and suitable for the production of a volume of wood per acre which will cover the costs of production.

3rd. *Extent to which Planting can be Profitably Carried.*—The area planted in any one block must be large enough to allow economical fencing, cultivation, supervision, management, &c., at a low cost per acre. It must not, on the other hand, produce a greater quantity of timber per annum than can be readily disposed of at a remunerative price, whichmay be put on an average at 6d. per cubic foot for conifers and 1s. for hardwoods.

4th. *Costs of Production and Yields of Timber per Acre.*—The costs of producing a crop of timber on waste land involve an average initial expenditure of about £8 per acre, interest on which, together with annual expenditure, must be allowed for until the crop is mature.

The annual average yield of timber from waste land varies from 40 cubic feet on poor situations and with slow growing species to 100 cubic feet on good situations and with fast growing species.

The average net returns per acre per annum from a properly selected area may be put at from 10s. to 15s., allowing for non-productive ground, and calculated on the basis of present prices for timber, labour and materials.

PART III.

FORMATION OF PLANTATIONS.

FENCING.

When a suitable area of ground has been selected for planting purposes, and the necessary negotiations with landowners and tenants have been terminated successfully, the

first step to be taken is that of fencing off the area from adjoining properties or grazing land, if such has not already been done. When fences are already in existence they often exhibit a great variety in their shape and form. Stone walls, turf dykes, posts and wire, hedges laid and trimmed, with and without banks, young and vigorous, old and gappy, may all be represented on the boundaries of an area of 500 to 1,000 acres, and it will be necessary to decide which of them shall be retained, which repaired, and which replaced by something more suitable.

The first thing to decide is what part of the boundary line is in need of effective fencing, and what it requires fencing against—sheep, cattle, rabbits or human trespassers. As a rule, boundaries adjoining arable land do not require fencing at all, or if so, only in a cheap form which will indicate the boundary. In the same way boundaries adjoining other woodlands require no fences, unless such woodlands happen to be grazed or run through by cattle. Boundaries adjoining public roads are usually fenced, although the fences are more often a warning than an obstacle to trespassers.

On the other hand, all boundary lines adjoining grazing grounds must be securely fenced, either by the owner of the plantation or by the owner of the grazing land, according to ancient custom or law. When fences already exist along a boundary line of two adjoining properties, they belong, as a rule, to one property or the other, and by the custom of the country their owner is bound to keep them in repair. When they do not exist, each owner is supposed to prevent his own stock from trespassing on the adjoining land either by herding or fencing. When, however, cattle are grazed on a common or on land held in common by two or more different owners, any enclosure made on it, either by Act of Parliament or by the owner exercising rights which have hitherto been in abeyance, must be made at the expense of the encloser. Land taken from a grazed and unfenced hillside for planting purposes, therefore, must be fenced by the intending planter against stock grazed by others, unless the legal obligations of the latter compel them to keep their stock on their own or a clearly defined area. Experience proves, however, that it is often more profitable for a plantation owner to fence his plantation against the live stock of adjoining owners than to run the risk of having his plantation ruined by cattle or sheep periodically breaking bounds, owing to the inefficiency of their owner's fences.

In the following particulars of various forms of fences, those relating to which is considered the best and most economical type in each class will alone be given. Farm and garden fences, and fences for particular purposes of an ornamental character, will not be dealt with.

Fences against Live Stock.

Posts and Wire.—When sheep and cattle must be fenced against, none but the strongest type of fence should be employed, whether it be dead or alive. The cheapest and most effective form of dead fence is that composed of posts and wires in conjunction with a low bank. The latter should be thrown up with a sloping face from two to three feet high, and the ground on the field side should slope gradually down to its base rather than be left in the form of a ditch, which will be continually trodden in by cattle. The face of the bank should be turfed, if turf can be had on the spot, and sloped gradually away at the top.

This bank not only prevents sheep creeping through the lower wires, but saves at least one wire in the fence, and by affording a firm support to the posts, keeps the fence firm and upright twice the time that it would be on the level. The fence should be erected about 6 inches above the base of the bank, and may consist of either split oak or sawn larch posts, 3 inches by 3 inches or 4 inches by 3 inches by 6 feet, pointed, and driven in 7 feet apart until the tops stand 3 feet 9 inches or 4 feet out of the ground. Strainers or turning posts should be 6 inches by 6 inches by 7 feet, pitted into the ground, and the former provided with winding brackets for each side. The whole of the posts should be creosoted or treated with preservative when thoroughly dry. Six wires should be used, the top either galvanized barb or No. 4 galvanised drawn steel wire, and the lower ones No. 6 of the same quality. Such a fence properly erected, and the wires tightened up from time to time, will stand twenty years at the least with ordinary treatment, and can be erected at a cost of 20s. per chain. If rabbits and overhanging trees are absent, a row of thorns, beech, or other hedge plants along the top of the bank will still further add to its efficiency and prevent the soil from crumbling away.

When sheep only have to be fenced against, a lower fence with lighter and shorter posts and fewer wires placed higher up the bank will suffice, and may be erected for 12s. to 15s. per chain.

Live Hedges.—On good strong ground a thorn hedge is the most satisfactory fence that can be employed, providing it is properly treated and protected from rabbits. On wet and stiff ground it should be planted on a low bank, similar to that described under posts and wire fence, but on fairly dry ground anything but a very low bank is objectionable. Two rows of thorns should be planted 9 to 12 inches apart, and when thoroughly established and at least an inch or so in diameter, they should be cut over close to the ground, and then kept trimmed or switched annually to the shape of a

wedge, and from 3 to 4 feet high. Owing to a hedge having to be protected by a fence on the outside for 8 or 10 years after planting, its cost at the outset is rather higher than an ordinary post and wire, but it far exceeds the latter in its durability, and will stand for 100 years or upwards. As a general rule, thorn hedges should not be planted on the north side of plantations, as the perpetual shade weakens their growth.

Dry Stone Walls or Dykes.—Stone walls can only be erected in districts where abundance of stone lies on or near the surface, and are probably more durable than any in the long run. Their initial cost, which may run from 1s. per yard upwards, is their worst feature, and unless the ground is too shallow for inserting posts, as may sometimes be the case when the boundary line crosses rocky ground, they may be considered too expensive for plantation fences.

Fencing against Rabbits.

When land is planted in the neighbourhood of other plantations or land frequented by rabbits, it is absolutely necessary to protect the trees against them in some shape or form. Netting them out is the only effectual method known at present and involves an additional expenditure of 4d. to 8d. per yard, in the fencing. When the netting can be fixed to the ordinary fence the lower additional sum will suffice, but when erected alone it can hardly be done properly under 8d. per yard and is a heavy tax upon the plantation. Not larger than 1¼-inch mesh should be used, and when fixed to a fence with a bank behind, a width of 30 inches will suffice as the lower end of the netting can be pegged firmly to the face of the bank and the upper tied to the second wire from the top. Fixed in this manner the cost is small. but the bank must be watched and all indications of burrowing into or under it treated with a mixture which will stop further mischief.

When erected by itself, netting must be let into the ground below and fastened to a wire supported on posts above. Netting 48 inches wide must be used in this case and should lean well outwards to prevent rabbits climbing over the top.

Fencing against Trespassers.

If a notice board with the awe-inspiring but untruthful legend, "Trespassers will be prosecuted," is not sufficient to deter trespass of a mischievous nature, a fence of some kind may have to be erected to stop lazy individuals, small children and so on; but a perfectly trespass-proof fence is too expensive for ordinary forestry purposes, except such as

a few lines of barb wire in the neighbourhood of villages or cottages. A ditch and bank should always be maintained alongside roads or public cartways, as these render it impossible for gipsies to take in their vans, or pilferers from slipping in with a pony or donkey and cart.

Draining and Cleaning the Ground.

After the ground has been fenced, attention must next be paid to such matters as draining and cleaning the land of all obstructions to planting.

Draining should usually be confined to the scouring and deepening of natural watercourses, and the tapping at their source of springs which break out over the surface. To attempt to drain plantation land in the systematic manner adopted in agriculture would mean a serious outlay, possibly accompanied by no adequate return. Naturally wet land must be planted with moisture-loving trees, and if stagnant surface water can be removed and the water of springs kept to one channel, little more is necessary, keeping economy in view. A good deal of useful draining may often be done after a plantation is planted, provided the main drains or leaders are formed at the outset. When a staff of men have to be regularly employed in a wood, a slack time can often be turned to account in this way, but it is certainly risky to spend large sums at the initial stage on work for which no return can be depended upon.

In deciding the extent to which draining work should be carried on, attention should first be directed to the outlet which the drainage water will have. It is little use drawing the water from one spot to convert a piece of comparatively dry ground into a swamp at a lower level. Natural watercourses can always be depended upon as main carriers, and the shortest line to these, or from one wet spot to another, fixed upon for the course of the main drains. These should be at least 2 feet deep on fairly level ground, while in places where they simply act as carriers the action of the water will tend to deepen them, and they may be made fairly shallow but wide, and left to fix their own depth.

In firm or strong ground the sides of wood drains should be almost perpendicular, and the bottom need not be more than 10 inches in width; but in soft, crumbly ground, as in peat or sand, they should slope more gradually and be wider at the top than at the bottom, and be made fairly shallow at first until the surface becomes firmer, and gradually deepened at each scouring.

The cost of draining runs from 2s. to 3s. per chain, according to the nature of the ground, but whatever the cost, an effort should be made to confine the drains as much as

possible to the best and deepest class of ground, and not attempt to drain shallow soils and rocky subsoils of low fertility, which will yield no adequate return for the cost incurred.

Cleaning the Ground.

The natural surface growth of rough or waste land may be either of an annual and temporary, or a woody and persistent nature. The former only interferes with young trees when they are small and unable to raise their heads above the level to which it reaches. Woody growth, on the other hand, may for a certain number of years keep pace with or outdistance the trees, and by weakening their growth in the early stages, prevent their proper development. In either case the roots of such growth rob the soil of plant food, and may deprive the trees of what would otherwise be available for them.

Annual growth usually consists of grass, fern or bracken, nettles, &c. Grass on poor soils rarely gives much trouble, but where it forms a dense thick turf, the roots of trees put in it are practically starved in dry summers until they find their way to the subsoil below. Where such exists, therefore, it must either be broken up by ordinary cultivation, or sites prepared for the plants by paring or skimming it off in patches of about a foot square. On hard or stiff soils the ground should be still further prepared by taking out a good spit or spadeful and returning it reversed. If this be done the autumn before planting, frost has a chance to act upon the soil and render it sweeter and more friable, and the plants can be slitted in the ordinary way the following spring.

Bracken is a very troublesome growth to deal with for the first two or three years, and if it can be got rid of or weakened before planting, so much the better. The cheapest way of dealing with it on a large scale is by cutting or breaking it over two or three times in the two preceding seasons, which will weaken its growth considerably. If this cannot be done, the ground should be prepared in the same way as for turf, and by chopping or skimming off the upper layer, a good many of the surface rhizomes will be cut through. Other surface growth is either too limited in extent, or of too harmless a nature for special measures to be taken in advance, and may be dealt with at the time of planting.

Woody Growths.

Woody growths likely to be met with are heather, gorse, broom, brambles, briers, thorns and the various ligneous

shrubs and smaller trees which may have established themselves in some way or another. Heather can be easily dealt with by burning, which should be done at least a season in advance of planting. When accompanied by turf or peat this should also be removed or broken up in the same way as grass turf, for dry peat is a very unfavourable medium for tree roots. With iron pan below the surface, this must be broken up at least six months before planting, either by a pick or bar being driven through it, or by subsoil ploughing.

Gorse and broom are the most troublesome of all surface growths to contend with, and it probably pays better to take drastic measures with them at the outset than to court disappointment later on. Both these growths can be easily got rid of for a year or two by burning, it is true, but the growth which springs up from the stools is of a denser and more injurious nature than before, and more difficult to deal with. The most effectual way of dealing with it is as follows :—The gorse or broom should be cut in April or May just as it is making its first growth. As it is cut, it should be stacked in parallel drifts or rows, with clear intervals of about three feet wide and six feet between. These intervals should then be roughly grubbed over, taking out all large roots, and as many smaller ones as possible, to a depth of six inches or so. This done, the whole should be left until June or July and then burnt as it lies by setting fire to the lines at suitable spots, and keeping men on the ground to keep the fires going. By this method, not only is the cut gorse destroyed, but the roots left in the ground are further weakened by the shoots which have started to spring from them in the meantime being destroyed, and all seedlings on the cleared space are scorched up by the heat. The following winter planting can be done on the grubbed strips, and the plants will have at least a good start before the gorse or broom recovers its original vigour.

Brambles, briers, and thorns can only be got rid of by grubbing and burning, but none of these are dense enough to strangle young trees if cut back from time to time until all danger is passed.

All the above forms of soil cleaning can be cheapened if horse labour or steam power can be employed in the work, and a strong grubber or cultivator used. With big stones or very uneven ground, this, of course, is impossible ; but a great deal of the more level tracts of heath, gorse, and bracken-covered ground can be dealt with by powerful implements and sufficient horse power or steam. When such is the case advantage should be taken of it, and the ground ploughed or grubbed, as the case may be.

Pit-planting is another form of soil preparation, which will be dealt with immediately.

Temporary Nurseries.

Whenever a large area of land is set apart for planting, an important preliminary is the setting out of an acre or two of ground for receiving and laying in the plants on their arrival and for bedding out any that may be left over from each season's work. Such ground should be free from stones, easily worked, fairly damp, but not of a sticky or clayey nature. Its position should be well sheltered from cold winds and be as central as possible for the work in hand. When selected the surface growth should be pared off, and as the plants are received they should be laid thinly in trenches and well trodden in, and remain there until required for planting. A mistake often made is that of laying in the trees in bundles as they are received from the public nursery. This should never be done unless they are to be planted out within a couple of days of their arrival, and not even then if there is the least doubt about this being done. Laid in in that way, the centre of the bundle gets dry in a very short time, unless the weather happens to be very wet, and should frost set in in the meantime nothing can be done to alter their position, and the chances are in favour of a large number of dead plants. Properly spread out in thin layers, plants take no more harm than if left standing in the nursery, and it is not improbable that they get acclimatised to a certain extent if planting does not take place until spring, as they are under the influence of the local climate throughout the winter.

Selection of Plants.

When planting operations on a large scale are decided upon, no time should be lost in selecting the plants required for the season's work. This can only be done after the ground has been carefully surveyed and the species for each class of soil selected. When the area and the distance apart at which each species is to be planted are known, the number of each species required can be easily ascertained by squaring the distance from plant to plant, and dividing the total area to be planted by the sum obtained. For instance, if Douglas Firs are to be planted at twelve feet apart each way on an acre of ground, the number required would be $4 \times 4 = \frac{4840}{16} = 302$. The number of acres to be planted with this or any other tree being known, the total number required is easily ascertained and steps taken to secure them.

An application to any respectable nurseryman, giving the

respective numbers and sizes required of each species, will usually be sufficient to obtain prompt quotations and samples if required. In selecting plants, preference should always be given to stout, stocky, well-rooted samples, even if slightly under size. Lanky, drawn-up plants, and probably badly rooted, never do well, and should be rejected however tempting the price. In fact, the rule in selecting plants should always be, select the best samples first, and look at the price afterwards. Work of this kind should always be done early in the autumn, and as soon as a selection has been made, the plants should be forwarded to their destination as soon as they are fit for lifting, and before any chance of hard frost exis's.

Laying Out Roads and Rides.

The question of making roads and rides through a plantation is not one which can be considered urgent at the time of its formation. To spend considerable sums on these items twenty or thirty years before they are likely to be used for carts or timber waggons cannot be considered good economy, and expense may well be spared until roads are likely to be required. But while actual outlay may be spared on them, the line they will eventually take in the case of roads and the laying out of green or unmetalled rides should be dealt with preparatory to planting the ground, so that the space occupied by them may remain unplanted and the natural herbage on the ground retained.

The manner in which rides should be laid out in a plantation depends upon the contour of the surface and the nature of the soil. When the surface is fairly flat and the soil dry and firm, rides should be laid out in such a manner as will provide convenient outlets for the timber without involving its being dragged or carried long distances. No part of a plantation on flat ground should lie further from the nearest ride than 100 yards, as the carrying out of poles or the dragging of timber for long distances is laborious in the one case and likely to prove injurious to the standing trees by barking them in the other. If the rides intersect each other at right angles, as they usually do on flat ground, the ground should be divided by them into squares of about ten acres in extent, having a side of 220 yards. This area is a convenient size for clearing and replanting when the time comes, and is also convenient for shooting purposes. The width of cross rides at the time of planting need not be more than 12 feet, while main rides should have a width of 24 feet, so that sun and air may keep them dry and well covered with grass or

heather, as the case may be, which aids considerably in bearing up wheeled traffic, and that width avoids the necessity of its being kept in the same track in wet weather.

On wet or swampy ground, rides should follow the line of main drains as much as possible, both in order to keep them dry and to avoid unnecessary crossing or bridging. In large plantations the ultimate formation of roads on the main rides will probably have to be undertaken, and care should be taken to lay them out on the firmest ground possible, even if their regular distribution should be interfered with thereby. The difficulty of removing heavy timber from wet woods is a serious obstacle to good prices being obtained, and every means should be employed to facilitate the formation and maintenance of serviceable roads and rides as much as possible.

On undulating or hilly ground the laying out of rides is a more complicated affair and must be carried out according to circumstances. They should follow the easiest lines from the high to the low ground or the adjoining high roads by which the timber must be removed, avoiding steep gradients and steep side slopes as much as possible. As a general rule all main rides or roads must be laid out along or near the bottoms of valleys into which the timber can be dragged or rolled from the slopes above. Lines which avoid the necessity for bridging rivers and ravines as much as possible should also be selected. As dragging must be largely employed in the removal of timber from hilly ground, the laying out of many side rides or tracks may be deferred until the necessity for them arises, and only the main rides should be studied at the time of planting.

Methods of Planting.

Planting may be conveniently dealt with according to the nature of the ground and the service growth which happens to be on it. On sandy loam, peaty sand, gravel, and all soils which have only a surface covering of heather, thin grass, or other growth, thin enough to enable the unoccupied soil below to be reached without difficulty, planting can be done cheaper and easier than on strong ground with a denser growth of natural herbage. On the former soils, small plants can be slitted or notched in, while pitting may be necessary on the latter.

Slit-Planting.

For slit-planting, two-year seedlings, or two-year seedlings transplanted for one year, are the best size to use,

according to the nature of the surface growth they are planted in. Larch, Scots Pine, Corsican Pine, Douglas Fir, and such fast growing hardwoods as Ash or Oak, which can fight their way upwards, do well enough when put out at two years if the strongest plants are selected, while the weaker ones should be put back in the nursery for another season.

Slow growing species, such as Spruce, Silver Fir, and Beech among hardwoods, should be at least three, and sometimes four years old, or from 6 to 12 inches before planting out, so that the slow growing period is passed before they are compelled to compete with surface growth.

Slit-planting consists in making two cuts with the spade at right angles to each other. In the L system of planting the cuts are made in the shape of that letter, and after making the last cut the handle of the spade is bent down, and the corner of the sod lifted up until the roots can be slipped in under the spade, which is then withdrawn by a quick movement and the sod falls back into its place and is trodden firmly down. In what is known as the T system the cuts are made to resemble that letter, and the top or cross cut is made last, and the handle of the spade bent down as before. This opens the leg of the T and the roots are drawn in at the widest part of the opening until the ends are past the top cut. The spade is then withdrawn as before.

Of these two methods, the L system is much the best, as the roots can be placed in the ground in their natural position. The great point is to see that the cuts are made straight, clean and deep enough, and that the roots lie perpendicularly between the two surfaces of the cut, and are not bent or twisted. Properly placed and trodden firmly in, the plants do as well as if pit-planted, and at a quarter the expense. A man and boy should plant, on suitable ground, 800 to 1,200 plants per day, and if skilful men are scarce, it will pay to let them do the slitting alone, and leave the treading-in to less expert men coming behind. The cost of slit-planting, exclusive of plants, runs from 10s. to 15s. per acre.

Pit-Planting.

This consists in taking out pits a foot square or so, according to the size of the plants used, holding the plants in position and returning the soil so that the best and finest is nearest the roots, and stones, &c., on the top. On hard ground or soils with strong turf or full of surface roots of any kind, pit-planting is also a form of soil preparation, as the roots and soil taken out are broken up and pulverised in the process, and rendered more suitable for the growth of the

trees. The two chief points to be observed are the depth to which the holes are taken out and the position in which the trees and roots are placed in them. The depth should always be greater than the length of the roots, so that the latter can be placed perpendicularly and entirely in the returned soil and not bent at right angles at the bottom of the pit. When placed in the latter way, not only is their development as wind-resisting anchors interfered with, but on hard or stiff soils the roots lie waterlogged at the bottom of the pit after heavy rain, or along the line of cracks in dry weather, and in either case their growth is interfered with. Another point is the placing of the plants in that corner of the pit furthest away from prevailing winds. When so placed, each plant is practically supported by firm ground on three sides, and the greatest root growth will take place in the direction in which it is needed, viz., towards the windy quarter.

The cost of pitting varies from 30s. to 50s. per acre for labour alone, while the extra size of plants used still further increases the total cost. On certain ground, however, it is the cheapest form of planting in the long run, as the plants are more quickly in a position to take care of themselves, and expense is thus saved in keeping them clear of rubbish.

The best sizes for pitting are two-year seedlings which have been transplanted and stood in the nursery lines until they are one or two feet high.

Best Season for Planting.

Although planting can be done at any time between September and May if the weather be mild and open, the chances of interruption from hard frosts are greater in December and January than in late autumn or early spring. When a large squad of men are specially employed for the work, it is important that the latter should go on with as little interruption as possible, and for this reason, if no other, planting should either be done in October or November, or deferred until February or March.

With hardwoods generally, and many conifers in sheltered positions, any one of the above months is equally suitable provided the roots are not unduly exposed. But with conifers of a delicate nature, such as Weymouth Pine, or bad transplanters, such as the Corsican or Austrian Pines, exposed situations should only be planted in late spring, so that the interval between transplanting and starting into growth is short, and the risk of exposure to cold dry winds at a critical stage is slight.

The nature of the soil should also decide to some extent the time at which planting is done. Cold wet soils are best

planted in late spring, as in such soils broken roots are apt to rot and decay rapidly in the winter months. Dry and warm ground, apt to suffer during the spring and summer drought, should be planted in the autumn if possible, as the plants then get fairly established before the following summer, and almost a year's growth is gained by so doing. When the entire area planted is made up of different soils with different exposures, therefore, it is possible to proceed during the greater part of an ordinary winter, and even during hard frosts and snow a good deal of such work as cleaning the ground, draining, grubbing rubbish, &c., can be done, and a fair squad of men kept employed if necessary.

Distance Apart at which Trees should be Planted.

The distance which separates tree from tree at the time of planting is not an important matter at the time of planting, provided that it is not too great on the one hand or too small on the other.

From three to four feet is a very good distance when pit-planting is adopted and the soil fairly good, as the greater cost of this method renders it imperative to keep the number per acre as low as possible, and the more rapid growth of the trees and the smaller risks of losses on good soil do away with the necessity for thick planting.

But with slit-planting on poor soils and exposed situations, three feet should be the greatest distance apart at which the trees should stand, as the extra expense of planting a few hundreds more per acre is small, while the necessity for the trees closing up their ranks is greater and the risk of losses is increased.

System of Planting.

Mixed Woods.—In the case of mixed plantations which are far more general than pure woods, not only has the distance from plant to plant to be considered, but also the distance at which the individuals of each species stand from each other. Woods may be mixed for several reasons, but the most common ones are, first, the desirability of introducing a species which is more useful in the form of thinnings than the main crop tree; second, the cheapening of the cost of planting by allowing less expensive species to act as "nurses" to scarcer or more costly ones; third, the provision of more favourable soil conditions by planting species with a heavy leaf fall amongst thin-foliaged trees; and fourth, the provision of two or three species in case one or more should fail to succeed.

In the first two cases the subordinate species must be planted on a larger scale than the main crop in order to produce the desired effect. The exact proportion one should bear to another depends upon the age at which the main crop species begins to form marketable timber. Oak and Beech, for instance, are of little value under 50 years of age. Ash and Spanish Chestnut, again, can be turned to account at 20 years of age or so. In woods intended to ultimately consist of Oak and Beech, therefore, profitable thinnings must consist of some other species up to the age of 50 years, and as by that time the total number of trees will not exceed one-fourth of the number originally planted, the remainder have either been crowded out as unprofitable individuals of those two species, or have consisted of nurses of Larch, Spruce, Pine, or early maturing hardwoods.

In the third case the numerical proportion of the subordinate species is of less consequence, so long as sufficient are present to furnish the necessary amount of humus or shade. Beech is the tree generally planted for this purpose, and as it will live throughout any ordinary rotation, its numbers at the time of planting may be comparatively small.

When mixtures are planted to ensure the existence of a species which will eventually come to maturity, each species is usually planted in about equal numbers, although quick maturing nurses may still be used to come out in the earlier thinnings.

As the combination of various species are of endless variety, it is impossible to lay down rules which would apply to all cases, but the most suitable as well as the most economical methods of mixing the species mentioned in Part II. may be given.

Plantations mixed to allow more economical planting or more profitable thinnings are such as consist of Oak, Beech, or Douglas Fir for the main crop. In the case of Oak or Beech, as already mentioned, young thinnings are practically useless owing to their small diameter, and faster growing species, such as Larch, Spruce, Ash, &c., must be used to nurse up the Oaks or Beech, and be capable at the same time of growing into something useful when the time of their removal comes. The usual distance apart at which these hardwoods are planted is either 12 or 16 feet, and the intervals filled up with other species until the whole of the ground is filled up at 3 or 4 feet intervals. With stiff, wet ground, Spruce should be used; good fresh or strong loam, Ash is the best species; and for light soils Larch will prove most profitable as subordinate species. In any of these soils, however, Larch may be depended upon for ten or twelve years, and should be put in alternately throughout.

When Ash is mixed in with Oak, the two should be planted in rows 8 feet apart, the Oak alternating with the Ash. Each of these species thus competes more closely with its own kind, and the danger of one species being outgrown by the faster rate of growth of the other is avoided. Every alternate row and every alternate plant may then consist of Larch, which will be the first to come out in the thinnings. The greater number of Oaks or Ash used by this method allow a large number to choose from in the early thinnings, and also allow for deaths and injuries which are sure to occur at some stage or another.

When Douglas Fir is intended for the main crop, a mixture is planted to economise the number of the former, which are comparatively expensive, and when planted pure the cost per acre becomes too high. The same principle may be followed as in the case of Oak or Beech ; Corsican Pine, Spruce or Silver Fir being used in alternate rows, and when planted at 12 to 16 feet apart each way they will usually close up completely in twenty-five to thirty years.

When woods are mixed for soil protection or improvement, as when Beech is mixed with Oak, Scots Pine or Larch, the Beech may be planted in much the same way as when intended for the main crop, as it can always be thinned out if necessary, and if rabbits are present, a fair number may be expected to disappear before middle age.

Mixing to secure a successful crop is usually practised when Larch is the principal species, and in such cases the system of mixing need not differ largely from that in those already mentioned. The species used, however, must depend upon the soil. In dry poor soils, in which, by-the-by, Larch need never be expected to live to a great age, Scots Pine and Corsican Pine, &c., may be used. In damper ground, Spruce or Silver Fir may be the species used, but whatever it be, care should be taken that the Larch is not ruined at the outset by being crushed out or smothered. On average soils Beech is the best tree that can be planted with Larch, as it neither interferes with the other in the early stages, and the shade and leaf-fall of Beech is particularly grateful to Larch in dry weather or on dry soils.

Pure Woods.

Pure woods are less trouble to plant and manage than mixed woods, but are rarely so profitable under ordinary circumstances as well balanced mixtures. The species usually planted pure are Scots Pine, Spruce, Larch, and Beech, and under conditions of soil and situation which are well adapted for one or the other of them alone, but only indifferently so

for other species. On poor dry soils Scots Pine probably gives as good a return, all things considered, when planted pure as any mixture. On thin but moderately damp soils, Spruce is about the only tree which will thrive for any length of time and on such is often planted pure.

Larch may be planted pure when a good and constant demand exists for it at a small size, as in the neighbourhood of collieries; or when the ground is so strewn with boulders or of such a broken nature that regular planting or a close order of growth is impossible. Beech may be grown pure after a time and when regenerated naturally on chalky hills, but it rarely pays to plant it pure at the outset for reasons already stated.

Marginal and Shelter Belts.

An important item in forming large plantations is the provision of judiciously planted belts round the margins and at exposed points, to shelter adjoining ground from the worst effects of rough winds. The neglect of this precaution is largely responsible for the havoc produced amongst shallow-rooting conifers by severe gales, and when once gaps are made, further damage is likely to be done.

In order to form a thoroughly efficient shelter belt round the margin of a plantation, the outside trees should be planted at least half a chain from the boundary. This avoids the necessity, which often arises in later life, for cutting or pruning up the lower branches on account of their overhanging adjoining ground, fences, or roads. A shelter belt should be clothed with branches to the ground on the outside, and no gaps of any size exist in it through which wind can sweep. The actual breadth of a belt need not be more than half a chain, but it should be planted throughout with deep-rooting and wind-resisting trees, so far as the nature of the soil will allow. On deep soils, Oak, Sycamore, Silver Fir, &c., should form the bulk of the inside trees, while the outside should be planted with such trees as Austrian Pine, Beech, and Hornbeam, and if effect is desired, Rhododendrons, Laurels, Hollies, and other evergreen shrubs. Such belts may be planted fairly thickly at first in order to hasten the closing up of the screen, but should be thinned in good time so as to induce a stout individual growth.

On thin soils a mixture of Beech, Mountain Pine, or any other stout bushy tree that will grow may be used, long-lived and hardy trees being the most useful.

Such belts, of course, should be considered as permanent fixtures as long as they will stand, and when gaps occur in

them through decay or old age, they should be filled up with the same class of tree. When ground is planted up in sections year by year, it is advisable to plant these belts at the outset, so that they may have a start of the inside trees and shelter the latter from the first.

Organisation of Planting Work.

When all the preliminary operations have been concluded and the plan of campaign, as it may be termed, has been decided upon, no time should be lost in making a start when the proper season arrives. On private estates planting is usually deferred until the spring, when all available hands are put on for about a month or six weeks and the work rushed through as quickly as possible. Under the prevailing conditions as regards sporting customs, labour supply and so on, this method is probably as good as any, as the woods cannot be entered, nor are the men available until the shooting season is over.

But when a large area has to be planted and no restrictions exist as to the time of doing it, it is far preferable to commence work with fewer men and to spread the work over a longer period than to employ a large gang at the end of the season and carry the work by storm. In the former case, not only can every spell of suitable weather be taken advantage of throughout the season and the different kinds of soil planted when they are in the best condition for it, or early or late in the season as may be most favourable to success, but interruption through frost or snow can be taken advantage of for the various processes of soil cleaning, hole digging, draining, &c., some or all of which can be done in most kinds of weather. As regards men, again, the fewer the number required, the less the necessity for taking on worthless or incompetent men and the more easy their supervision becomes. With men unaccustomed to the work, some little time is needed before they get into the proper groove, and the longer the time they are employed at it the smaller the proportion of badly executed work is likely to be done. Men, too, who are engaged for the whole winter can usually be obtained at a cheaper rate than those taken on for a few weeks only and are more likely to take an intelligent interest in their work.

The exact number of hands likely to be required depends of course upon the extent of ground to be planted and the nature of the soil or method of planting. Allowing each man an average of one workable week to plant an acre, and a total period of ten weeks throughout the season of planting weather

it follows that each man regularly employed from October to March should get over ten acres of ground. Allowing half the number of boys to that of men for carrying and holding plants, &c., the number of men and boys required to plant a given number of acres is soon arrived at. In addition to the planting hands a foreman will be required to set out the work, arrange the species in their proper order, keep time, and see that the work is properly done, and so on.

The precise part of a piece of ground at which planting should commence is not of so much importance as the planting of particular soils when in the proper condition, or particular trees or situations at the right season. Dry soils and warm sunny situations should always be planted as early in the season as possible, so that the roots may get fairly established before dry spring weather sets in. Wet stiff ground, on the other hand, should only be planted very early or very late in the season as may be most convenient, so that the soil may be warm enough to encourage root action at once. Exposed situations and species that transplant badly, such as Corsican or Austrian Pines, should be planted fairly late in spring, so that cold dry winds may be past their worst, and the plants ready to start into growth at once. Such species as Larch or hardwoods, which are deciduous, may be planted at almost any time through the winter. Scots Pine, Spruce, or Silver Fir should be planted in spring only if it can be conveniently arranged, but if care be taken not to expose the roots, they may be planted in autumn or winter. As a general rule all dry ground should be planted before the 1st of March, and wet ground or exposed situations between that date and the beginning or middle of April, according to latitude. In the North of Scotland planting may continue up to May; in the South of England it should be finished by the 1st of April at the latest.

The best way of proceeding with the work is somewhat as follows:—

The number of planters or hole diggers, as the case may be, being known, the ground to be planted or holed should be measured off in strips with a width equal to the distance between the rows multiplied by the number of men at work. For instance, if twelve men are to be employed in planting or holing at 4 feet apart, the width of every strip dealt with simultaneously would be 12 by 4, equal to 48 feet or 16 yards. At intervals of 16 yards, therefore, sticks with a piece of white paper should be stuck up in lines across or along the ground, so that the outside on the right or left of the squad can follow these lines with his eye as he proceeds. Each man in between measures his distance from the man on his left,

but the man on the line of the sticks takes these as his guide only, and thus the width of each strip or drift remains the same, and errors of measurement from man to man do not affect the rows outside that particular strip, which might otherwise be thrown out of proportion throughout the whole work. If a man or two should be short at any time, their rows should be left and taken by other men on the return drift, so that one man is always working on, and the others from the true line, and the number of plants or holes allowed per acre is not exceeded by faulty measurements.

When planting mixed plantations, each planter should plant one, or at the most two, species only, otherwise confusion will ensue, or time be wasted in ascertaining the order in which each species should be planted. If pit-planting is being done, the simplest way is for the foreman to place out the plants in each hole in advance of the planters, so that the latter only have to plant them as they go on, and all confusion is avoided. With slit-planting, the less common kinds may be pit-planted in advance by the most intelligent men provided with measuring rods to get their distance, while the other men follow on with the nurses. When Larch is used as a common nurse, each boy should supply two men, handing them alternately to the right and left, while other species are supplied by other boys, the plants being held on their left arms and handed out by their right.

Each day's supply of plants should be handed out by the foreman from the temporary nursery, counted, and tied up into convenient bundles with soft twine. These should be carried or carted to the centre of the day's work, and covered with wet fern, grass, or other rubbish, and only such a quantity removed from it at once as can be planted within half an hour. Next to placing the roots in a proper position and firmly treading in, the success of all planting operations depends upon the keeping of the roots moist as much as anything, and too much attention cannot be paid to this point.

Although planting by piece work is not to be recommended, care being more important than speed, yet every inducement should be given to secure smart and energetic work. This may be done by giving a weekly bonus whenever more than a minimum number of plants have been put in, provided that the foreman can certify that the work has been properly done. The bonus should be divided equally between the men, while individual skill or energy may be rewarded by a slightly increased rate of pay, given on the recommendation of the foreman. It should always be remembered that one skilful planter is worth two careless ones, and if the latter

show no signs of improvement as time goes on, they should be weeded out or given other employment.

PART IV.

MANAGEMENT FOR FIRST TWENTY YEARS.

When once a plantation has been properly planted and all blanks filled up during the second season, little remains to be done for the first ten or twelve years. Such growth, however, as bracken, brambles, &c., requires carefully watching for at least two or three years after planting, and bracken may have to be cut twice in a season. All this, however, is work which any ordinary labourer can attend to so long as he is careful not to cut or injure the trees in cutting the rubbish. To avoid this a broad hoe rather than a sickle or hook should be used in the work, the former being quite sufficient if used in time and before growth becomes woody. All indications of ground game should be watched for inside the plantation, and measures taken to remove it at once by trapping, ferretting, or shooting, a sharp terrier being specially useful in such work.

THINNING.

The first thinning or cleaning may require to be done about the tenth or fifteenth year after planting, according to the growth of the trees and the composition of the plantation. In pure woods on poor soil thinning is rarely necessary before the fifteenth year, and not even then with some species. Mixed plantations in which Larch has been used with Oak or other slow-growing hardwoods will usually require attention by the tenth year or so, in order to prevent the latter being overdrawn and weakened. But with most species the chief work at this stage consists of removing small, diseased and deformed trees, and in doing any necessary pruning to the hardwoods. The first process should be the cutting out of the rubbish, which may either consist of small suppressed trees which never made a proper start, or of weedy individuals wedged in between two fast-growing trees.

Both of these two classes of trees should be cut and any worth trimming up carried out to the nearest ride. The rows containing the hardwoods should then be gone along, and all Oaks, &c., relieved from encroaching branches of Larch, Spruce or other trees, which may be cut off with a hedge knife as far up as a man can reach. If the Oak has been planted on the system recommended in Part III., the Larch standing between every two must be severely pruned, if not already cut out. The Oaks themselves should also be attended to, double leaders cut out, and strong side branches shortened back, so as to encourage the formation of straight single stems. This thinning and pruning will carry the plantation on for another five years or so, when the first heavy thinning out of the Larch must be made. Probably fully half of the trees originally planted will by this time have disappeared or become suppressed, leaving about 1,200 to 1,500 trees to the acre, which will average about 20 feet in height. This thinning, therefore, must reduce their number to from 800 to 1,000 trees per acre, leaving the Oaks entirely alone in their rows, and taking out the majority of the Larch on either side, between which stands the Ash and Larch row, which must also be thinned. The value of the thinnings removed at this stage should average about £4 per acre, and will, of course, more than pay the expense, and nothing more should be required for several years. All plantations in which Larch forms three-fourths of the original crop, and the remainder consist of light-demanders, may be thinned out in much the same way as the above. With shade-bearers, such as Spruce, Beech, Silver Fir, &c., or fast-growing trees, such as Corsican Pine or Douglas Fir, the thinning of the Larch may be chiefly confined to suppressed trees, as the former will suffer little or no injury from overshading, and the latter will suppress the Larch without assistance. The leading shoots of the slower growing trees should, however, be relieved of all side branches that happen to be rubbing them and all diseased or deformed trees weeded out.

The management of pure woods is very simple. All that is required is to take out the suppressed trees about the twelfth or fifteenth year, according to growth and the light requirements of the species. Such species as Beech, Spruce, or Silver Fir scarcely require touching until the twentieth year, and only the entirely suppressed trees removed when the value of the thinning will pay for the work. The great fault with most British plantations consisting of these species is the branchy and knotty character of the timber they produce, and this can only be avoided by close order throughout, and thinning in the ordinary sense of the word may be almost entirely neglected.

PART V.

PROBABLE RETURNS FROM PLANTATIONS BETWEEN THE TWENTIETH YEAR AND THE END OF THE ROTATION.

Returns from Thinning.

The age at which profitable thinnings may be expected from a plantation depends upon the species on the one hand and the demand for small timber on the other. In the case of Larch, all thinnings after the twelfth year or so may be considered profitable, as so many different uses may be found for Larch poles of any size. With other species, such as Spruce, Scots Fir, &c., the value of thinnings depends entirely upon the local demand for pit-wood, which is practically the only purpose for which such material is wanted, and the demand for which is unlimited if the cost of carriage can be overcome. Few hardwoods, except Ash and Spanish Chestnut, afford profitable thinnings before the fiftieth year, and only then when the local demand is good. In fact, local demand may be said to determine the profit on thinnings of all species with a large proportion of sapwood, or which have only a small length of clean stem, owing to their low value per foot and inferior quality. As a general rule early thinnings of nearly all species, except those mentioned above, are not worth more than half the value of mature timber per cubic foot; and as the cost of carriage is much the same in either case, it follows that small thinnings cannot be sold at a price which leaves anything to the grower after the cost of the work is allowed for, unless a use can be found for them on the spot. As a matter of fact it is often found that the thinnings of plantations in outlying districts are unsaleable at any price, except, perhaps, in small quantities, and they have either to be given away or lie and rot on the ground.

The conclusion to be drawn from the above facts is, therefore, that early thinnings, apart from sylvicultural requirements, should be entirely avoided, unless the local demand and prices obtainable are such as will render them a source of profit. In most districts both Larch and Ash sell well at anything over twenty years of age, while in colliery districts thinnings of most conifers can be sold profitably at thirty or forty years, or with a mean diameter of 6 inches. But apart from these instances, thinnings under fifty years of age, which are simply confined to the suppressed and partially suppressed trees, are not sources of much profit, although they may be able to cover the expense incurred in making them.

As regards returns from thinnings, therefore, ordinary

forest trees may be conveniently divided into two classes: first, those which are valuable immediately they reach the small pole stage, such as Larch, Ash, or Spanish Chestnut, and, secondly, those which must be of fair size and possess a fair proportion of heartwood or clean stem before their value exceeds that of firewood. As already mentioned, these facts are generally recognised when Larch is planted freely amongst hardwoods or slow maturing conifers, or Ash mixed with Oak on good ground, and when such a system is adopted the thinnings are confined as much as possible to these quick maturing species, and their value is the chief indication of the profits possible from thinnings. If the size and number of these "nurse" trees available for removal at the various stages of a plantation's life can be ascertained, therefore the value of the thinnings can be estimated with tolerable accuracy.

Of the total number of trees planted in forming a plantation, it will generally be found that from two-thirds to three-fourths have disappeared or have died out by the twentieth year, leaving from 700 to 1,000 still standing. With Larch, planted in the proportion of three to one of any other species, it is obvious that the majority of the removed trees will belong to the former. Assuming that the plantation has not been thinned since the twelfth or fifteenth year, and that it contains 1,000 trees per acre, 600 of which are Larch, there will be at least 300 of the latter to be removed, which will be worth from 2d. to 4d. each. By the thirtieth year another 200 will have to be weeded out, worth 1s. 6d. each, and by the fortieth year the majority of the Larch will have disappeared, unless they happen to be filling up gaps caused by the death of other species. By the fiftieth year, therefore, the plantation should consist practically of hardwoods only, or whatever the main crop tree may be, and stand from 200 to 400 to the acre. If these consist of light-demanders, such as Oak, Ash, or Pine, still further thinnings must be made until from 100 to 200 of the best trees alone remain. But if Beech, Spruce, or Silver Fir form the main crop, at least 300 trees should be left until maturity is reached, or nearly so.

The value of these later thinnings will depend upon the species. Ash, Pine and Spruce will probably be worth nearly as much as mature timber per cubic foot. Oak, if clean and sound, should also sell well, but Beech in most districts is worth little until the seventieth or eightieth year. On an average, however, the thinnings from Oak, Ash, and Pine between the fiftieth year and maturity will total up to about 1,000 feet per acre, worth about £50, £75 and £25 respectively. Beech, Spruce, and Silver Fir may amount to 2,000 feet in the same period, each worth about £40.

On the above assumption, which of course can only be taken as a general estimate of intermediate returns, the following would be the yield and values received from the thinnings of a plantation in which Larch nurses constituted the bulk of the thinnings for the first 50 years :—

Period.	Trees removed.	Value. £	s.	d.
15—20 years ...	300 at 3d. ...	3	15	0
21—30 „ ...	200 at 1s. 6d. ...	15	0	0
31—40 „ ...	50 at 3s. ...	7	10	0
	Hardwoods ...	5	0	0
		38	15	0
51 and upwards ...	... ...	50	0	0
		88	15	0

Where the main crop tree consists of Beech, Spruce, or Silver Fir, the value of the Larch thinnings should be higher than is shown above, as they would be able to stand longer, and therefore become more valuable. With Douglas Fir, Corsican Pine, &c., they might be lower owing to being more quickly crushed out. But on the average about £40 worth of Larch thinnings during the first fifty years is a fair estimate on fairly good soils and with a good demand.

The thinnings of pure woods, unless they happen to be Larch, are seldom so profitable as the example given above. Ash, perhaps, comes nearest to Larch, but requires the best of soil, and can only be represented to a limited extent on waste land. Scots Pine, Corsican Pine, and Spruce thinnings are seldom of any value under thirty years of age, and should be carried out on a moderate scale if the ultimate results are to be good. In the case of all pure woods it is generally found to pay best when nothing but suppressed trees are taken out up to middle age, and then heavier thinnings gradually made after height growth has practically finished By so doing the largest bulk of clean timber will be obtained and the quality will be all that can be desired. In such cases the value of the thinnings will increase as time goes on, and will probably be equal to that of the final falling, or a total of £80 to £100 per acre according to species.

Returns from Final Fellings.

When the average annual yields given in Part II. are examined, it is not a difficult matter to estimate the approximate quantity of timber standing on an acre of ground at a

given time after middle age. Of course no two individual acres will carry exactly the same stock of timber, for not only does the productive capacity of the soil and situation vary in each plantation, but the degree of thinning extended to it considerably affects the amount of timber standing at the final felling. The latter, therefore, must always be an unknown quantity until actual measurements have been made, for it is obvious that a thinning ten or fifteen years before the final clearing will decrease the latter considerably, although it may increase the size of individual trees. Probably the most economical method is that of thinning moderately up to within twenty or thirty years of maturity, and then taking out the smaller trees until from 50 to 100 of the best remain to the acre, according to their size.

When Larch is grown pure and cut at fifty or sixty years of age, fairly heavy yields may be expected at the final felling—3,000 to 4,000 cubic feet per acre, worth about £150 to £200. Scots Pine at eighty years of age may contain 5,000 feet, and be worth £100 to £150, while Spruce or Silver Fir at a hundred or more years of age may yield from 6,000 to 10,000 feet, and be worth £120 to £200 if a ready sale exists. For such yields and returns good soils and situations are needed, and good markets must exist.

The best final yields in volume of hardwoods are usually obtained from Beech, and the highest returns in money from Oak and Ash. But, as a general rule, the final clearings of hardwoods, owing to the greater length of the rotations, are more uncertain than in the case of conifers, and everything depends upon the normal development of the crop.

Average Returns from Plantations.

Taking the class of land more particularly under review, it may be stated that the value of the thinnings during the first half or more of the rotation equals about one-fifth, the later thinnings about one-fourth, and the final fellings about two-thirds of the total returns throughout the rotation. As the value of the total returns on an average rotation of eighty years should not be put at more than £200, it follows that £40, £50, and £110 are the highest probable returns from these periods respectively. Where, however, early thinnings are of little or no value, about one-third of the total may be put down to thinnings generally, and the remainder to the final clearing. If an average total return of £150 per acre can be obtained from land not worth more than 5s. per acre for agricultural purposes, no difficulty should be experienced in securing the average net annual yield of 10s. to 15s. per acre which has been stated as possible from a well-managed area.

But it must also be recollected that many risks attend the raising of timber crops which are absent from grazing rents, and therefore the ultimate returns from land under timber must be high enough to cover these risks, otherwise planting becomes more or less a speculation.

Another point which requires attention is the fact that a large area of plantation land invariably contains a certain proportion, possibly 10 per cent., which is non-productive, owing to the rides, margins, and swampy or sterile ground, and therefore the timber on the actually productive area must pay not only the rent of the ground it stands on, but that of the unwooded portion as well.

The chances of profit from planting operations, therefore, must not be cut too fine, or a balance on the wrong side may result.

Returns from Sporting Rents.

Although the rents paid for the shooting rights over woods are not often included under the head of probable returns, yet it is a well-known fact that they vary from 2s. 6d. to 5s. per acre, and add considerably to the value of a large and compact area. No doubt the usual presence of large numbers of rabbits in preserved woods causes most foresters to look upon the rents derived from shooting as a very imperfect form of compensation for damage done by ground game. But, as a matter of fact, it is possible to prohibit the encouragement or preserving of rabbits and yet get fair shooting rents at the same time. Of course, when no restrictions are in force a shooting tenant can, and naturally does, make the most of his rights and as good a head of rabbits as can be had will be encouraged. When the shooting is let in a plantation of young trees, therefore, a strict clause should be inserted in the agreement reserving to the proprietor the right to kill rabbits at any time of the year, and classifying those animals as vermin pure and simple. If this be done, and the rabbits are kept down strictly from the first, no good reason exists for the plantation not being made use of for game preserving after the first ten or fifteen years, and a rent obtained little, if at all, below the grazing value of the land.

Conclusion.

If the foregoing statements be accepted as correct, no impartial reviewer of the facts can deny that a very large area of land exists in Great Britain which may be profitably afforested. In carrying out work of this kind successfully, however, the selection of suitable land is of the first importance, for although abundant proofs are forthcoming that

timber can be profitably produced on otherwise waste or nearly waste land, it does not follow that all such land is adapted for such purpose. As a matter of fact, it is not at all probable that more than one-fourth of the 13,000,000 acres of mountain and heath land in Great Britain can be planted profitably under existing conditions. How far this statement would hold good if British grown timber were to increase in value to any extent it is impossible to say, but the fact must not be overlooked that Great Britain is not the only country in the possession of this class of land. Scandinavia, for instance, has vast tracts which are probably worthless for any other purpose than timber growing, and if the growing stock has been reduced to vanishing point by improvidence, time and systematic management are only needed to restore their productive capacity. Norway and Sweden, for instance, have about 70,000,000 acres under forest all lying within comparatively easy distance of shipping ports, while Finland is also as well stocked with forest and as favourably situated.

All of the above countries are within two or three days' sail of British ports and timber can be carried over at cheap rates. According to present requirements, about 500,000,000 cubic feet of pine and spruce timber are imported into this country, the value of which is about three-fourths of the total value of timber imports. Allowing average forest land to produce 20 cubic feet annually per acre if put under systematic management, it follows that about 25,000,000 acres are needed to produce the quantity annually imported.

Of the chief exporting countries which now supply this quantity, Sweden, Norway, and Finland send about one-third. These three countries have between them about 120,000,000 acres of nominal forest, which, it may be assumed, have a productive capacity equal to the waste lands of Great Britain. It is quite conceivable, therefore, that a general introduction of systematic measures in the management of Scandinavian forests might ultimately result in an annual output of coniferous timber equal to or in excess of the requirements of Northern Europe, for Russia has more than enough to satisfy her own requirements and the imports required by Germany and France.

Although the above facts may have no direct connection with the planting of two or three millions of acres of waste land suitable for the purpose in Great Britain, yet they enable one to compare the relative extent of timber growing operations possible in this country with the existing forest areas of neighbouring countries. In the latter the greater part of the forest soil is already stocked with a natural crop of some kind, and an artificial one could probably be produced at far less cost than would be the case in this country.

Extensive planting operations in Great Britain, therefore, should be undertaken more with a view to the better and more economical utilisation of semi-waste land, the increase of its capital value, and the general development of rural industries than with any definite ideas of rendering this country independent of foreign supplies of timber. Not only is the available area insufficient to bring about the latter result, but the climate of Great Britain is better adapted for the production of hardwoods and quick-growing conifers than for the slow growth of Pine and Spruce which renders the latter of such value for economic purposes, and the supply of which at present prices is only made possible by extremely low or nominal costs of production, which would be out of the question in Great Britain.

A. C. FORBES.

"*Adaptation of land which has either gone "out of cultivation or which has only a very low "rentable value for afforestation: showing the mode "of procedure from taking the land over, and for "twenty years after; and some statistics as to what "returns may be looked for from this period up "to maturity.*"

The above title is prescribed by the Worshipful Company of Carpenters for an Essay, and I have accordingly treated the subject in the following order :—

1.—Introduction, showing the imports of timber into the United Kingdom, and that there is a large area of waste land and of agricultural land of low rentable value, part of which may with advantage be devoted to forest growth. Our internal sources of supply of building timber are becoming restricted and prices are rising.

2.—A description of the general character of our present woodlands, distinguishing between those that are stocked with indigenous trees, and others planted with exotics, and including some statistics regarding the pecuniary yield of the different species.

3.—The different systems under which woodland may be advantageously managed in the United Kingdom are then discussed.

4.—The classes of land are then considered which are unremunerative under agriculture, and may therefore be planted with trees.

5.—Descriptions follow of the mode of treatment to be adopted in stocking land of these different classes with trees and of the tending of the plantations until they are twenty years old.

6.—Finally, a short account is given of the further tending of these plantations until they have become mature, and of the probable financial results.

I.—INTRODUCTION.

The annual imports of timber and manufactured wood-products into the United Kingdom are enormous, the figures taken from the official Trade Returns for 1902 being as follows:—

	Tons.	Value.
Coniferous Timber	8,983,818	£19 875,431
Wood Pulp (chiefly coniferous)...	525,799	2,398,215
Oak and other broad-leaved wood, which might be grown in Britain	455,635	3,141,010
Staves (chiefly Oak)	195,569	728,805
Total	10,160,821	£26,143,461

	Tons.	Value.
Mahogany, Teak and other exotic woods, not producible in Britain	337,243	£2,501,641
Value of wood manufactures, house-fittings, turnery, etc.	—	2,465,674
Total Value		£31,110,776

Much of the raw material of the wood manufactures could also be grown here, but omitting that, there is an annual import of more than £26,000,000 worth of wood, which might be grown in the British Isles, provided there is land available for the necessary plantations. The volume of this wood, being about 10,000,000 tons, is probably the produce of nearly 10,000,000 acres, although, with the favourable conditions for tree growth in the British Isles, half that area might suffice to produce it.

The area of woodland in the United Kingdom is about 3,000,000 acres, which under present conditions should produce at least as many tons of wood annually, but I believe that no figures are available regarding their yield, although it could with advantage be given in the Agricultural returns alongside the yield from agricultural crops. There can, however, be no doubt that the produce from our existing woodlands might be considerably increased, were they fully stocked and their management improved, and especially if rabbits were kept in check. We have 47,752,000 acres of

cultivated land out of a total area of 76,549,000 acres, leaving 28,797,000 acres not under agriculture, much of which is doubtless built over, or consists of roads and railways, but 16,692,000 acres are mountain and heath land unsuitable for agriculture. Much of this land consists of high lying grouse moors or deer forest, and is probably unsuitable for sylviculture, or at any rate the first crop of trees grown there would not prove remuneratve, although as humus accumulates in the soil under forest growth, a second crop might prove more valuable. The rent per acre of this class of land is very low, from a few pence in the west of Ireland and one shilling an acre on the average for the whole of Sutherland, to four shillings an acre in England; large areas of it might certainly be planted profitably, especially in Wales, whilst the area still given in the returns as agricultural land includes much rough pasturage, which would yield a better return under timber than it does at present. No figures are however available to show the area of uncultivated land in the United Kingdom which could be profitably converted into woodland, although from the observation of anyone who travels much in the country, such tracts must be of considerable extent. It would be extremely useful if the Agricultural Department were to collect statistics showing areas of low rented land which might be profitably planted.

Another point which has been repeatedly proved in public by Dr. Schlich, is that, owing to the increasing population and consequently increased demand for building timber all over the world, the sources of supply of soft woods are becoming greatly restricted, the United States being forced to import largely from Canada, while Russia, Austria, and Scandinavia are the only European timber-exporting countries. Europe has an annual deficit of 2,750,000 tons of timber, and imports largely from Canada, and to a less extent from tropical and semi-tropical countries where chiefly hard woods are grown. There is no systematic forest management in Canada, from which consequently a permanent supply of timber is uncertain. Prices of oak-wood and of coniferous timber are consequently rising, and have risen 18 per cent. since 1894.

The above facts tend to show that the British Isles constitute the best timber market in the world, whilst the sources of our supply are being curtailed, and it is certain that our national wealth would be greatly increased were our woodlands extended and well managed; there are also certainly large tracts of land of unknown area available for planting, which readily succeeds in our moist climate. The presence of extensive woodlands in Britain would also cause the establishment of large industrial works using native timber as raw material and employing much labour. In order, however, to

make forestry pay in this country, land must be planted economically, and I would here draw attention to the fact that, in large areas of continental woodland, fences are unknown, and these constitute a serious item of expenditure in plantations. This charge on plantations would be eliminated, were fencing debited to game, or to agriculture, and the fences are really needed either to keep rabbits, cattle, and sheep out of plantations, or trespassers out of game preserves. Another point in favour of continental forestry is the fact that the reproduction of many existing woods is secured by seed from mother trees left standing temporarily in a shelter-wood, which is gradually removed when the trees are mature. Fences are not always required in Britain, as may be seen in extensive pine plantations now being made in the Bagshot sands district, and natural regeneration by seed and coppice shoots is largely resorted to in our coppices-with-standards, while the Chiltern Hill woods are regenerated by seed falling from the Beech trees and are frequently left unfenced.

In a lecture recently given by Dr. Schlich at the Royal Agricultural College, Cirencester, he shows, that provided our woodlands pay 2½ per cent. on the capital invested, *i.e.*, on the value of the land and cost of planting and maintenance, this should be quite a sufficient rate of interest, as woodlands constitute a steadier investment than Consols, the fluctuations in which of late years have been considerable. He has also given some valuable statistics on the average cost and yield of plantations on land of medium quality, which are summarised below :—

Name of Tree.	Price per cubic foot.		Most profitable rotation in years.	Yield per acre in cubic feet.	Cost of planting per acre.		Cost of an acre when Wood is mature, with compound interest 2½ per cent.	Value of Land per acre, which when planted pays 2½ per cent.		
	s.	d.			£	s.	£	£	s.	d.
OAK	1	5	130	46	6	0	149	9	11	0
BEECH	0	11	120	57	5	0	97	9	17	0
SCOTCH PINE.	0	8	80	70	4	0	29	14	5	0
SPRUCE ...	0	7	90	84	3	10	32	15	1	0
SILVER FIR ...	0	8	120	111	5	0	97	16	6	0
ASH	1	5	70	40	6	0	34	24	0	0
LARCH	0	11	70	73	4	10	25	34	2	0

For better land the rotations might be less, or the yield greater, and when the cost of the land is higher than the figure given in the last column, less than 2½ per cent.

FIG. 1.

interest would be obtained, while if the land is cheaper, a higher interest would result. From my own experience of the growth of Beech and Silver Fir south of the River Trent and in Wales and Ireland, I believe that mature crops of these species can be grown in 80 or 90 years, but Dr. Schlich's figures are average figures for the whole of the British Isles. I also believe that the price of mature Oak and Ash timber is nearer 2s. per cubic foot than 1s. 5d. In all these cases quarter-girth and not solid measurement of the timber is pre-supposed.

As regards the financial returns from copses, the net revenue of one of these woods, 789 acres belonging to the Crown, was, in the ten years ending in 1894, £1 1s. 11d. per acre. A French forest of this class, near Valenciennes, with 14 years' rotation of the underwood, yields a net annual revenue of £1 2s. 6d. per acre, although the woods are not in a condition to produce the maximum yield from the excellent soil they cover.

Fig. 1 shows part of this forest, after the underwood has been cleared, the standards being Oak, Ash and Poplar, and the underwood chiefly Alder.

II.—DESCRIPTION OF THE GENERAL CHARACTER OF OUR WOODLANDS.

I now propose to describe the general character of our woodlands, first, those stocked with indigenous trees, secondly, those that are planted with exotics.

1. OUR NATIVE WOODLANDS.

Oak, Beech, and Scotch Pine are the chief native species of trees that are extensively grown in Britain.

Oak occurs mainly as standards over coppice, and thrives in our moist climate, wherever the soil is deep and moist enough, both in the lowlands and in hills up to 1,000 feet above sea-level. There are many small areas of pure sessile Oak woods in Wales, where this tree reproduces itself naturally by acorns, and it is important in hilly districts throughout Britain to plant only the sessile Oak, as the pedunculate Oak requires plenty of moisture in the soil and thrives in the lowlands, where it is thoroughly at home. In our copses, the pedunculate Oak frequently reproduces itself from acorns, but it is often planted. The rotation of the underwood is usually about ten years, too short to enable it to force up the boles of the Oak standards, which are generally about 25 feet long. The rotation of the underwood has, however, been raised to 25 years in the High Meadows Wood, near the Forest of Dean, and Oaks there become tall and valuable,

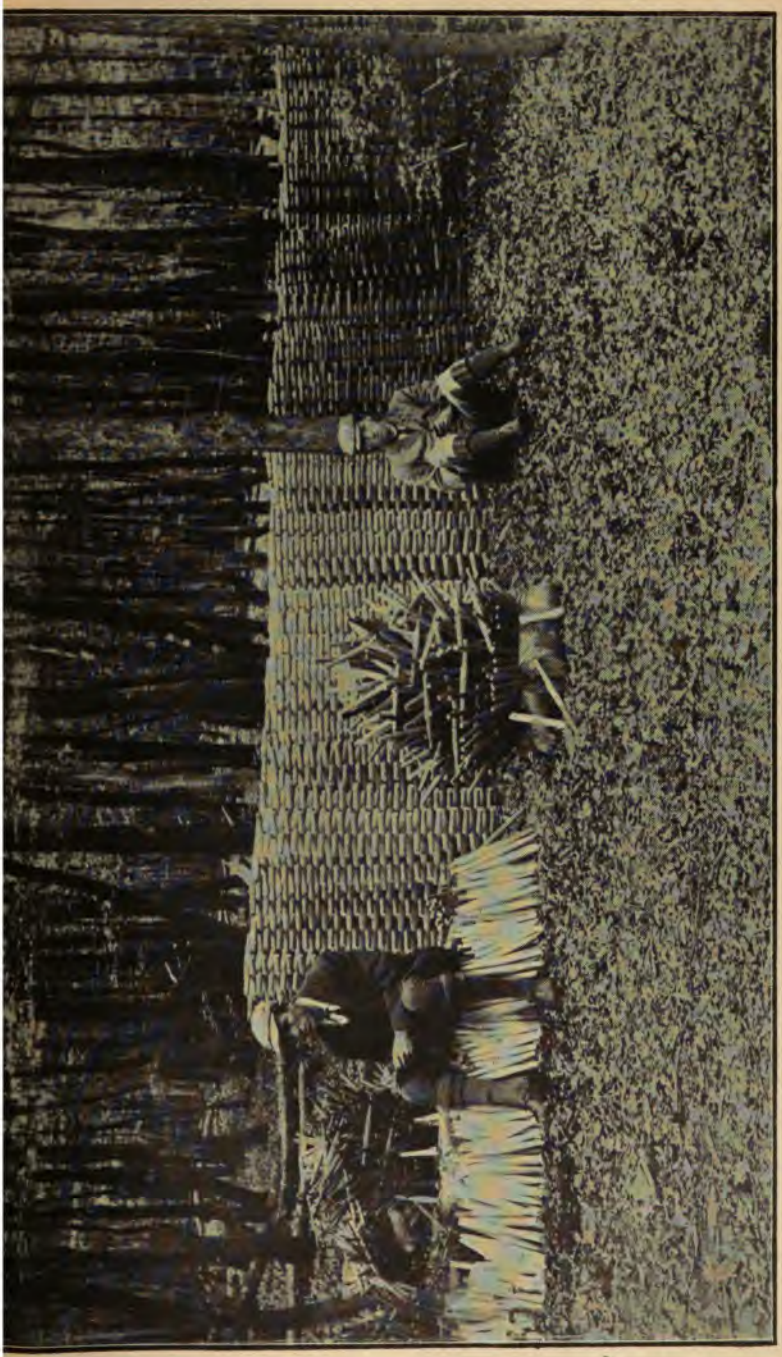


FIG. 2.

while the longer and larger underwood is suitable for pit timber. With only ten years rotation, however, underwood is used for barrel hoops, crate-wood, fencing stakes, chisel-wood (in Cumberland), broom handles, tree-props, bean-sticks, and firewood. Such small underwood is still saleable near large towns, but its value in country districts is small, hazel hoops, which were formerly remunerative, having been largely supplanted by iron hooping. Such woods also yield Oak bark for tanning, from the felled standards, and this at any rate pays for the cost of felling the Oak trees, and leaves a small margin of profit.

I have measured seven felled Oak standards growing on the London clay, the average age of which is 77 years, and the average volume 31 cubic feet (quarter-girth measurement). They were sold standing at 2s. 6d. per cubic foot, and their average price was consequently £3 17s. 6d. each.

The management of woods under coppice-with-standards or copse is very simple. There are as many compartments of equal area as there are years in the rotation of the underwood, and successive compartments are exploited annually, all the underwood being felled and such of the standards as are either mature, defective or overcrowded, after the underwood has been cleared. The standards are partly regenerated naturally by seed, but it is better to plant, say twenty saplings for every mature standard felled. Besides Oak ; Ash, Larch, Poplars, Birch, and Elm standards may be grown over the underwood. Wherever underwood sells readily, this type of woodland is admirable for the private owner and it affords excellent pheasant cover.

There are a few small areas of pedunculate Oak high forest, 200 years old, in the Windsor and New Forests, and in these, Oak attains a chest-height girth of 10 feet and a total height of 100 to 120 feet. Such a forest of Oak when 100 years old, produces stems five feet in girth, but there is much sapwood, and the trees are not really mature under 160 to 200 years.

Beech Woods prevail in the Chiltern Hills, and consist of high forest managed under the Selection system, being exclusively regenerated by seed falling from the trees, so that the expenses of management are very low. The fellings are repeated over the same areas, every seven or eight years, trees of about three-and-a-half feet in girth and 80 or 90 years old being felled, so as to thin the crop evenly at every felling. The produce is chiefly used for chairmaking, as is shown in Fig. 2.

These woods were in bad condition in the early part of last century until they were enclosed, and were formerly grazed by cattle and freely felled for fuel. Since they have been enclosed, most of them have been overfelled,

FIG. 3.

and as the Beech tree produces fertile seed only after it is about sixty years old, some of these woods are now too young for natural regeneration by seed. In spite of these disadvantages the net annual revenue of many of these woods exceeds £1 per acre and as the demand for Beech timber is very great, there can be no doubt that with lighter fellings and better care, they would eventually yield thirty shillings an acre. They are not exclusively composed of Beech, but contain a mixture of fine straight Oak trees and and of wild Cherry and Wych Elm. The Oaks in these woods are generally used for estate purposes, and their value is not included in the revenue. Beech will grow everywhere in the British Isles, where the soil is fairly drained, but not too dry.

The Beech forest of Soignes, near Brussels, with a rotation of 100 years, which has been admirably managed, yields a net annual revenue of £2 per acre, and there is no reason why some of our British Beech woods should not yield as much.

Fig. 3 represents part of the French Beech forest of Retz, near Compiègne, and this with 150 years rotation yields 82½ solid cubic feet of timber annually, but much of this yield is only firewood, and the net annual revenue is about 15s. per acre, the average price of Beechwood there being only 2½d. per cubic foot, compared with 11*d.* in the Chiltern Hills. The long rotation is maintained chiefly to allow for a mixture of fine Oak trees with the Beech, and there is a considerable quantity of Hornbeam most of which comes out in the thinnings. The value of the forest of Retz is being rapidly increased by the introduction of Oak, which will eventually form one-third of the crop and Figure four shows a fine oak such as is grown in French Beech forests.

Scotch Pine grows freely on sandy soils throughout Britain, and there are considerable areas of this species in the Bagshot sands district, where it was introduced about 80 years ago. The quality of the wood there is not nearly so good as in Scotland, where the tree is indigenous. Even on the Bagshot sand, however, fully stocked Scotch Pine woods, eighty years old, yield 4,300 cubic feet per acre (quarter-girth measurement), worth £107 10s., at 6d. a cubic foot. Most of these woods have been so overthinned as not to yield more than half this amount of timber, when mature.

Fig. 5 shows a Scotch Pine wood growing on extremely shallow soil above a shingly gravel, in the Bagshot sands district. Scotch Pine woods in Britain are generally completely cleared when mature and replanted artificially, but natural regeneration is easy to secure and may be adopted, unless there is a pan near the surface, which has to be broken through, and then artifical plantations are necessary.

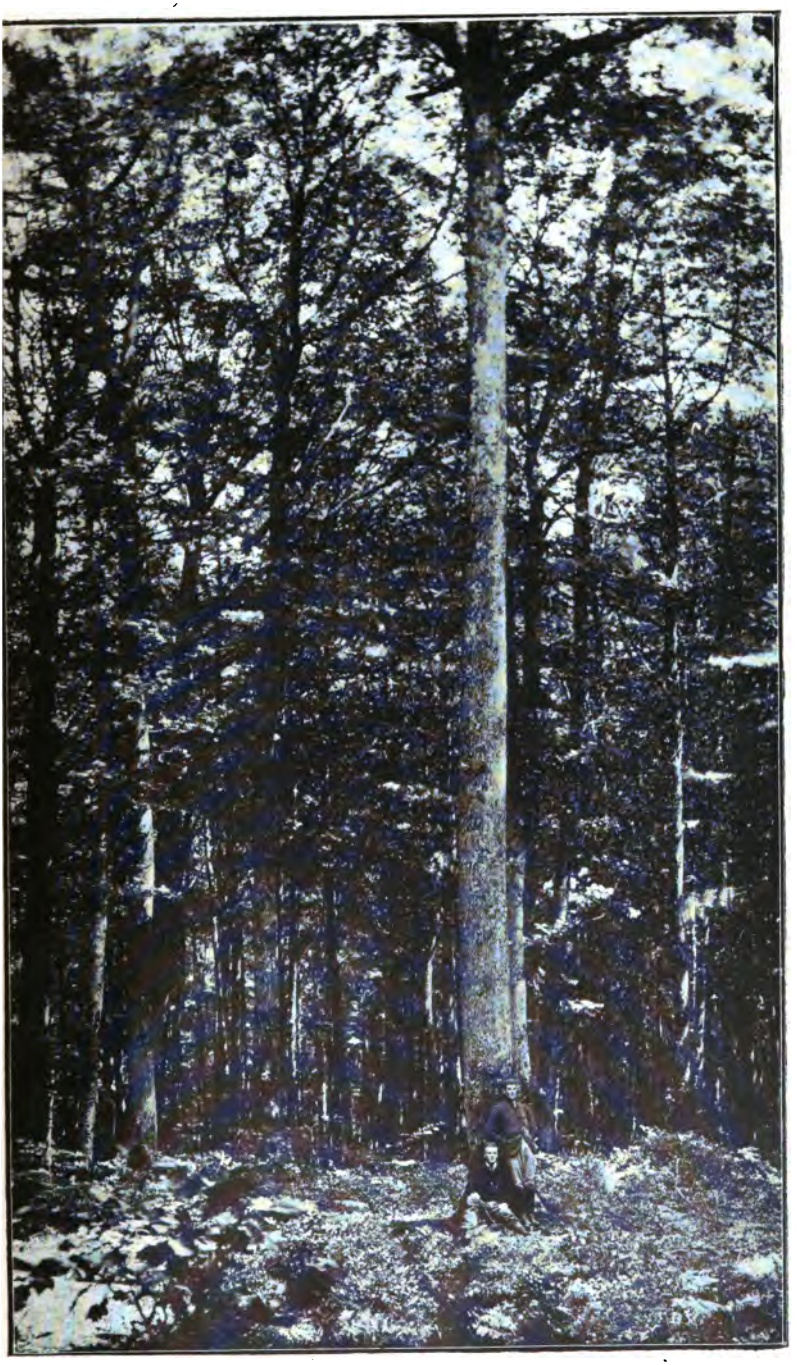


FIG. 4.

Besides Oak, Beech, and Scotch Pine, which occur in extensive woods, the following indigenous trees are grown, either mixed with the above species, or in small woods, namely; Ash, Sycamore, Alder, Birch, Poplars, Willows, and Hornbeam.

Except **Birch**, which springs up naturally in other woods, after a felling has been made, and though valuable for bobbin wood is too shortlived and small a tree to be extensively cultivated, the other trees here mentioned require special kinds of soil to thrive. **Ash** is one of our most valuable trees, and may be grown as a standard over coppice or as underwood. Sycamore also requires a good soil, but may be grown in Beech forests, whenever the soil is suitable. Large **Sycamore** trees sell at 2s. 6d. and more per cubic foot. Alder will grow on very wet soil, and is in general demand for clogs and gunpowder. It has been somewhat extensively planted in the valley of the river Kennet, and was formerly abundant in Wales, where it has mostly been cut out by the clogmakers, who work up the wood *in situ* as do many chairmakers in the Chiltern Hills. Alder forms splendid coppice underwood, attaining a height of 45 feet and more with 25 years rotation, and with Alder underwood, splendid pedunculate Oak and Ash standards may be grown, though owing to the rapid growth of the Alder, fine saplings of those trees should be planted at each felling and carefully protected from the coppice shots.

The Black, White, and Canadian (an exotic) **Poplars** and Hybrids between these and Aspen, such as the Grey Poplar, are fast-growing trees on a suitable deep and moist alluvial soil. They are extensively grown on small areas of wet ground by the French peasantry, sometimes with Alder underwood, and in 30 years attain a height of 100 feet with girths up to six feet at chest-height, and then yield about 80 cubic feet (quarter-girth) of timber per tree. These Poplar woods are often sold standing at £2 per acre to the proprietors of travelling saw-mills, who use a traction-engine to transport their plant and sawyers, the engine when at rest driving a circular saw. The wood is sawn into planks and scantling, and is used for rafters, joists, the lining of carts, and furniture, and for lucifer matches and packing cases. I have been informed that Poplar wood sells at 1s. per cubic foot in Gloucestershire, and doubtless, if sufficient material were available, an important industry in Poplar wood might be established in Britain.

Tree Willows also require moist and deep alluvial soil, but are very valuable for making cricket-bats, which can be cut from maiden Willows, 25 to 30 years old.

Osier Willows form a special crop by river-sides on land liable to be flooded, and otherwise of little use. Hornbeam

FIG. 5.

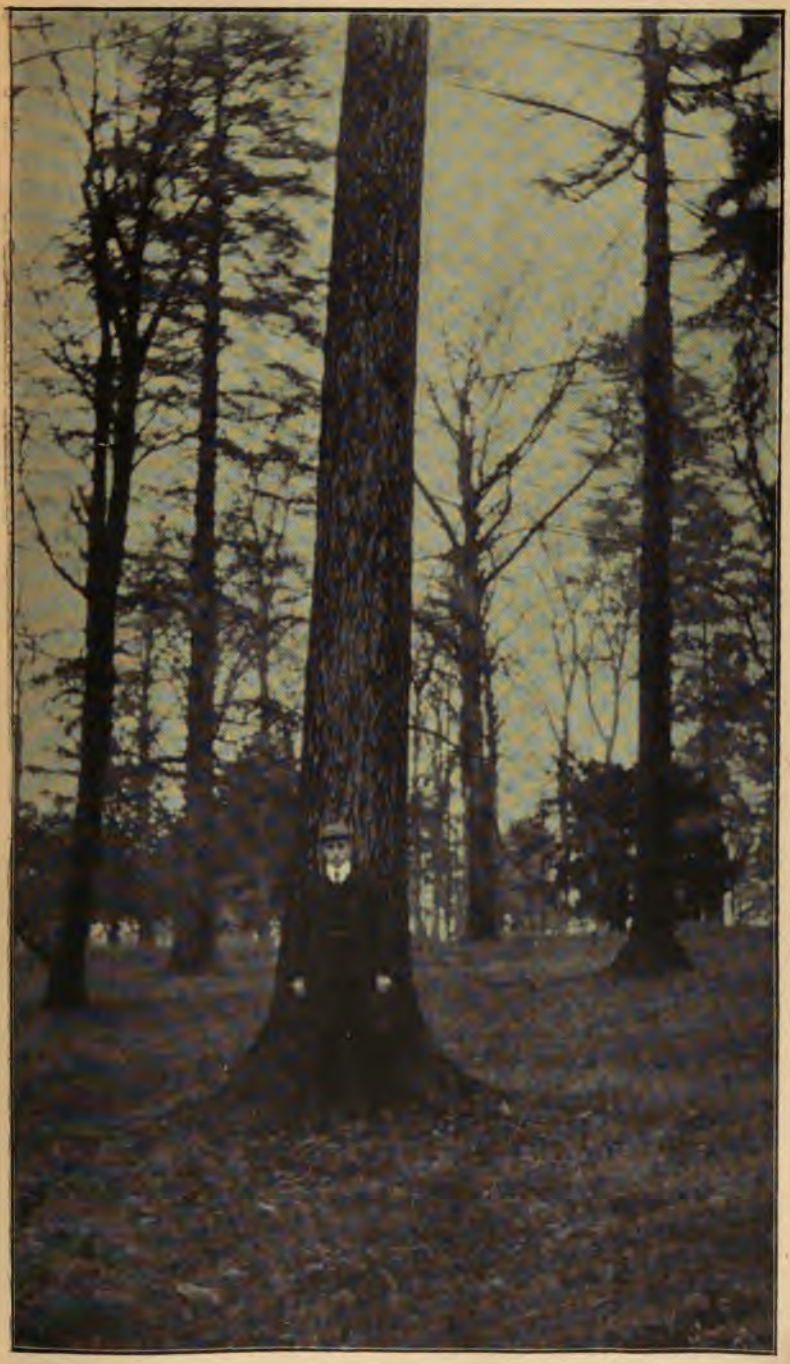
is extensively grown in Epping Forest and forms pure forests in Russia. In this country it is usually too small a tree to thrive in high forest, and shades the underwood too much as a standard over coppice. It forms, however, excellent coppice underwood, and withstands frost well.

2. EXOTIC TREES.

The chief exotic trees grown in British are Larch, Spruce, Silver Fir, Douglas Fir, Weymouth and Corsican Pines, and Spanish Chestnut. Of these, the **Larch** is most extensively grown and is very valuable, an acre of Larch wood near Bray in Ireland having been sold, when 64 years old, for £127. This tree, however, is so subject to disease, owing to the ravages of a fungus (*Dasycypha Willkommii*) that only in exceptionally favourable localities should it be grown pure. Mixed with Beech, Silver Fir, or Spruce, or over coppice, however, it attains large dimensions, and may still be safely grown. Siberian and Japanese Larch may prove more immune from this disease than the common Larch, but the former is a poor tree, and the latter is still too expensive to be grown on a large scale, and suffers from frost when young, though experimental plantings of Japanese larch are advisable. Figures six and seven show how well Larch grows with Beech and Silver Fir in the Windsor forest, where Larch trees attain 8 feet in girth and 100 feet in height in 92 years.

Spruce, in my opinion, is not likely to give good returns except in the North of England or Scotland, as its wood when grown in the South of England or in Ireland is very soft and of little value. In Scotland, however, there is no reason why this tree may not be grown with advantage, provided the woods are sufficiently dense to ensure slow diameter-growth and freedom from knots. In Saxony, Spruce woods with 80 years rotation yield on the average 92 solid cubic feet of wood per acre (68 cubic feet quarter-girth measure) with a net revenue of £1 2s. 6d., although the average price of the wood is only 4½d. per cubic foot. Dr. Schlich states that there are forests in Saxony, which yield double the above-mentioned revenue.

Although **Silver Fir** has never been extensively grown in the British Isles, one finds the tree everywhere, and it regenerates itself naturally in Lord Leicester's woods in Norfolk and elsewhere. Its wood, when grown in Britain, is of much better quality than that of Spruce, and the danger to which when young it is exposed by frost may be avoided by sowing it under pre-existing shelter-wood of Larch, Birch, or Oak. Silver Fir woods are extensively grown in Normandy, where the climate resembles that of the South and West of England and the greater part of Ireland. Once this tree has grown to maturity, its management in forests is extremely simple, as it reproduces itself naturally from



Photographed by] FIG. 6. [*Mr. Ellis.*

seed under the Selection System, in much the same way as Beech in the Chiltern Hills. Broillard estimates the annual yield of Silver Fir woods in France, when mature trees are four feet in girth at chest-height, as 84 solid cubic feet per acre (62 cubic feet quarter-girth measurement), and as Silver Fir wood is fully worth 8d. a cubic foot in England, this amounts to £2 per acre annually. The growth of this species is more rapid in England than in Normandy, and I have measured Silver Fir trees in Windsor forest (Figs. 8 and 9) 100 feet in bole, and 9 feet in girth at chest-height, which were planted in 1812.

Pacific **Douglas Fir** grows faster than Silver Fir, and also reproduces itself naturally in Berkshire. The following statement taken from Dr. Schlich's address at Cirencester shows the yield of this tree at Taymouth on the Earl of Mansfield's estate. Originally the wood consisted of 1,200 plants to the acre, 400 Douglas Fir and 800 Larch. It was planted with four years' old plants in 1860, the Larch was cut out in 1880, and in 1887, half the Douglas Fir were cut out and sold for £4 8s. per acre. Since then, the remaining 200 trees per acre, now 47 years old, have been allowed to grow up, and in 1903 averaged 16 inches in diameter at chest-height and 82 feet in height, with a volume of 10,218 cubic feet per acre. This gives a mean increment of 217 solid cubic feet, or 163 cubic feet (quarter-girth measurement), worth about 1s. per cubic foot, or £8 per acre annually. This is the highest economic return ever produced by any tree in temperate regions.

The Colorado Douglas Fir is hardier against frost than the Pacific variety, and can be planted in the open, which is hardly possible with Silver Fir, but it will not probably prove more remunerative than the latter, though there is evidently a great future for the Pacific Douglas Fir, in situations where it will thrive. Its wood was specially selected by Dr. Nansen for the construction of the "Fram."

Weymouth Pine is known as a very useful species to mix with Scotch Pine on sandy soils that are too poor for better species, and owing to its shade-bearing qualities, it greatly improves the growth of its companion and increases the volume of timber produced.

Spanish Chestnut grows rapidly on sandy soils that are too poor for Oak, and reproduces itself naturally both by seed and coppice in the south of England and in Ireland. It may readily be grown with Beech, and yields timber 70 to 100 feet high and 8 feet and more in girth at chest-height, when 100 years old. This tree also forms splendid coppice attaining a height of 40 feet with basal girths of 1½ to 2 feet, when only 12 years old. There is very little sap-wood in

Photographed by] FIG. 7. [*Mr. Ellis.*

such poles, which yield durable material for hop-poles, pit-timber, hurdles and other purposes.

I have thus summarily described the species which we can plant, but have omitted Corsican Pine, as no returns from mature woods of this species are available, although its cultivation is now frequently undertaken on account of its excellent timber and the fact that it withstands strong gales better than other trees, and may thus form wind-firm protective belts to our woods. *Sequoia sempervirens*, Californian redwood, probably grows quicker than any other conifer in Britain.

III.—CHOICE OF SYSTEM.

The next question is FIRST, whether to grow trees in high forest, or in coppice-with-standards; and, SECONDLY, whether to clear-cut the trees when mature and replant or sow artificially; or, THIRDLY, whether we should reproduce them naturally by seed, thinning out the mature crop and leaving a temporary shelter-wood to sow up the ground and shelter the young growth till it can thrive without cover. Oak and Ash are probably best grown by private agency as standards over coppice, and a certain amount of Larch may be similarly grown. If Beech or Silver Fir are grown, the Selection System with natural regeneration may be followed, or the more complicated shelter-wood compartment system for Beech, though not for Silver Fir. I believe that Douglas Fir may also be grown in Selection woods. Spanish Chestnut can also be reproduced naturally by seed, in the South of England, and in Ireland, where this valuable tree deserves more attention, but the Selection System is not suitable for its production. It may be grown pure up to 30 or 40 years, and then thinned out and under-planted with Douglas Fir or Weymouth Pine, which may be cut out when the Chestnuts are 90 years old, and the latter then reproduced naturally by seed. Oaks may be similarly grown on suitable soils, but will not be mature before 130 to 150 years; in France rotations of 150 to 200 years are usually adopted for Oak high forest, but in Germany the tendency is to reduce the rotation of this tree to 130 years.

Scotch Pine may be grown either by natural regeneration under a shelter-wood, or may be clear-cut when mature, but in such a case the land must be left unstocked for three years until the stumps have dried up, for fear of the Pine-weevil, which breeds in the cambium of such stumps. Larch and Spruce woods should also generally be clear-cut and replanted artificially, and the same plan must be adopted with Poplars and Tree-willows.

hotographed by] FIG. 8. [*Mr. Ellis.*

IV.—CLASSES OF LAND AVAILABLE FOR PLANTING.

The classes of land in Britain, which are agriculturally unremunerative, are generally of the following classes.

(*a*) Sandy heather land.

(*b*) Peat-bog, specially prevalent in Ireland, and Fen-land.

(*c*) Clay-land or loam, too heavy to be ploughed remuneratively now that the price of wheat is low.

(*d*) Inferior pasture land on loamy or sandy soil.

(*e*) Land on hill-sides that is very stony or covered with boulders.

(*f*) Land on chalk or limestone rock, with superficial soil frequently full of flints.

In the moist climate of the British Isles, such lands, although agriculturally unproductive, may yield excellent crops of timber.

V.—MODES OF TREATMENT TO BE ADOPTED IN STOCKING TRACTS OF THE ABOVE LANDS WITH TREES AND IN TENDING THE LATTER UNTIL THEY ARE TWENTY YEARS OLD.

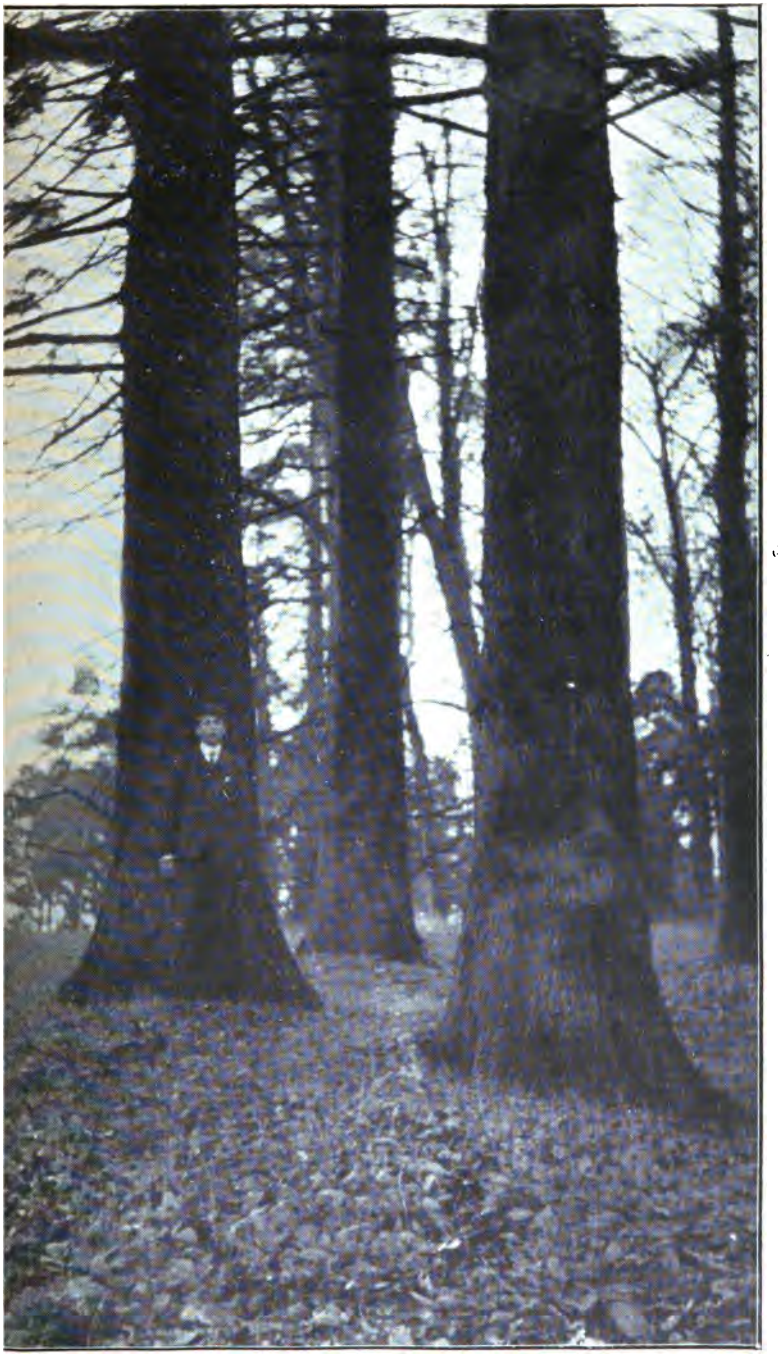
Before any planting is commenced, it is necessary to consult a forest expert, who should draw up a scheme of operations, after inspection of the locality; so that he can decide on the species to be planted and the system to be adopted. A good working forester should also be engaged to carry out the planting operations, and his work should from time to time be inspected by the Forest Expert.

In commencing the plantation, if it is intended eventually to have a large area under high forest, say of 4,000 acres, the question of future felling-series should be considered, and the compartments planted in any particular year, and in successive years, should be arranged so as to form good felling-series, contrary to the direction of the prevailing winds, and so that the felling-areas in any particular year will not be too large at any particular point of the wood. All this requires expert knowledge, but the way it should be secured can hardly be properly considered here.

(*a*) Sandy Heather Land.

(1) General Description of Locality.

There are in Britian very extensive tracts of heather land, which are at present let for very low rents, often only a few pence per acre, for sheep pasture, but provided the altitude



Photographed by] FIG. 9 [*Mr Ellis.*

does not exceed 1,200 feet, they would generally yield productive crops of trees. If such land does not contain an impenetrable pan, within a foot or so of the surface, its planting presents no particular difficulty. Wherever a superficial pan exists, the soil-covering is usually heather, but in other cases bracken gorse or grass may cover the ground, and then the soil is more favourable for planting. A natural growth of Birch frequently springs up on such land, especially after the heather has been burned; stunted. Sallows, Oaks, and Aspen are scattered over it, but on lands covered with heather, Scotch and Weymouth Pines are usually the best species to be cultivated, at any rate, as a first crop, although after the land has been enriched by their needles and the heath killed by their shade. Larch and Spanish Chestnut may be grown, as well as Douglas Fir, Spruce, or Beech.

(2) FENCING, ETC.

We will assume that a tract of 4,000 acres of heather land is available for planting, and propose to plant 50 acres of it annually, which is as much as one woodman can conveniently supervise. It is important in this and all cases to plant the area from north-east to south-west, so that eventually when fellings are made, they may be contrary to the direction of the prevailing strong winds, modifications in the direction being made whenever the prevalent winds are diverted from the normal direction of such winds in the British Isles, owing to the intervention of hills. Coppices are sometimes planted from south-west to north-east in order to shelter the shoots against cutting north-east winds wherever these are dangerous, but Coppice should not be grown on very sandy land. The first condition for successful planting is that rabbits are kept down, which may be easily done by systematic ferreting and trapping, the sale of the rabbits covering the expense. If, however, the the land borders on properties where rabbits are preserved, fencing with wire-netting becomes necessary, although its erection considerably increases the outlay. The cost of fencing with wire-netting, including the cost of erection, may be put at £1 12s. 6d. per 100 yards, and for a plantation of 50 acres, assuming the ground to be 440 yards wide by 600 yards long, 2,080 yards of fencing will be required. In succeeding years, as one side of this fencing will not be required, and part of the fence can be taken up and used again, only about 1,600 yards of fencing will be used. The cost of fencing would therefore be about £35 for the first year and about £27 in succeeding years, although it may frequently suffice to fence only along the border endangered by rabbits and to leave the rest of the plantations unfenced. As, however, the whole plantation of 50 acres would not generally be in one continuous compartment, fencing would usually cost more, say £1 per acre.

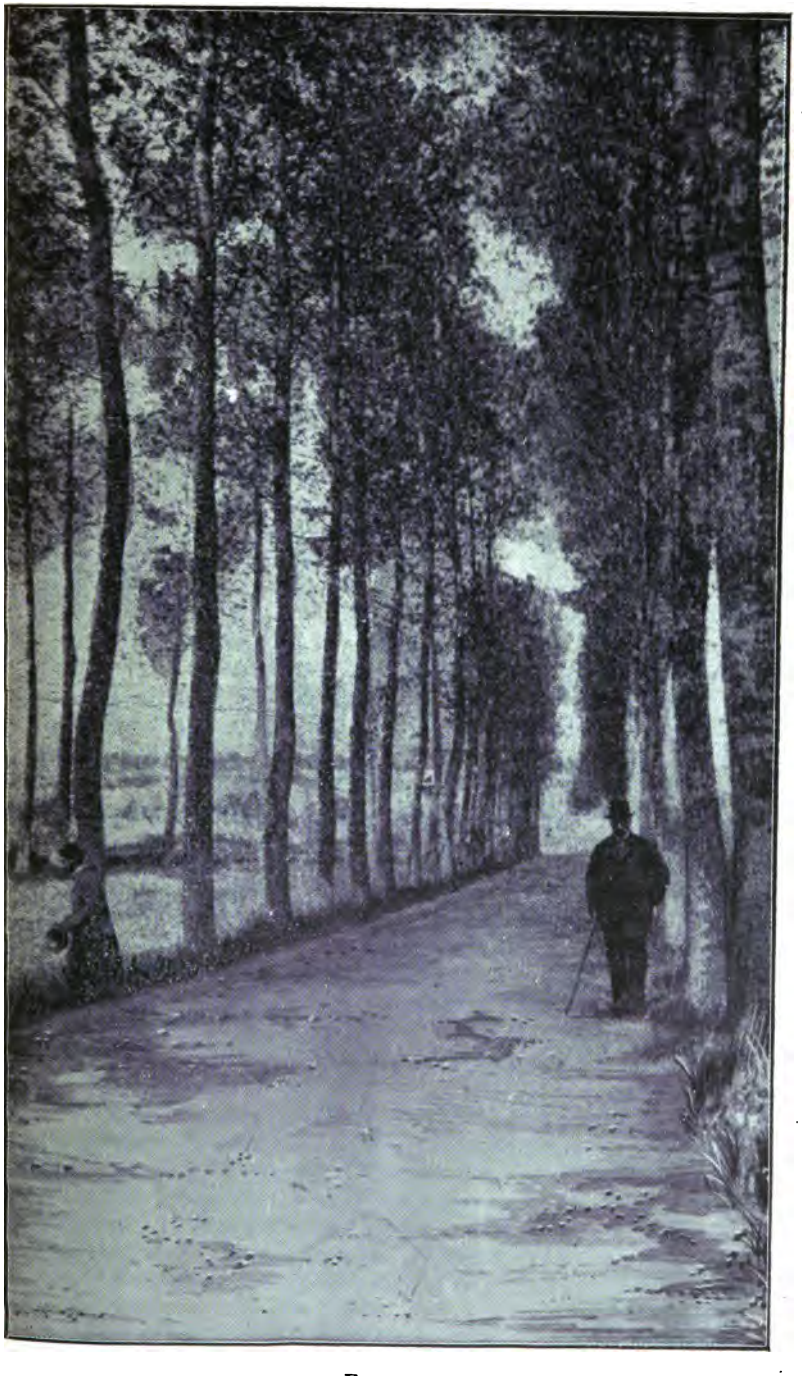


FIG. 10.

Plantations without any fencing are now being carried out in the Bagshot sands district.

(3) Preliminary Clearing.

The question of fencing having been decided, the next question is what to do with the soil-covering of heather and other plants. It is quite possible to plant in standing heather, and this shelters the young plants from wind, sun and frost, but there is always great danger from fire to plantations made in standing heather. In all cases a wide clearing of at least 100 feet of the heather should be made round the proposed plantation, so as to exclude fires from without. This may often be done by selling the heather to farmers, or by allowing them to cut it free of charge. Where this cannot be done it is often best to burn the old heather carefully, as the fresh shoots of heather after a fire are short and not readily inflammable. In case it be thought too dangerous to leave the heather standing on the site of the future plantation, it may also be burned in the spring and summer preceding the planting.

Bracken and gorse must be cut during the summer preceding the planting, as this greatly weakens the future growth of these plants, which would otherwise choke the young transplants; and the cost of this clearance should not exceed 30s. per acre for gorse and 2s. 6d. per acre for bracken. A growth of grass on heather land is rarely too high to interfere with planting, and the best thing to be done in such a case is to have it browsed down by sheep in the summer preceding the planting.

Before commencing planting, a map should be made of the area to be planted, on which roads and rides dividing the land into compartments should be shown. There is, however, no necessity to make the roads until the plantations are nearly ready to be thinned; but their position should be shown on the map, and gradually marked out on the ground as the planting proceeds. The roads should be 20 feet wide and the rides 10 feet wide. The roads will eventually be metalled, but this is not necessary for the rides, which may, however, be roughly levelled wherever the ground would otherwise be difficult for walking.

4. Planting Operations.

The next question to consider is the presence or absence of a pan, which is commonly found on heather land. If the pan is lower than 1½ feet, it may be neglected, but if it be nearer the surface, its presence causes swamps in wet weather and prevents water from percolating upwards in dry weather, so that the surface is frequently very dry in summer and is liable to be waterlogged in winter. The proper method of planting to be adopted then is pitting, each pit one foot

square, being dug with a spade down to the pan and the latter broken through with a pickaxe or crowbar. Communication is thus secured between the surface soil and the subsoil, and surface water then drains down below the pan, while in dry weather, the roots of the plants obtain water from the subsoil.

Pitting with breakage of the pan is expensive, and the planting should be four feet by four feet for four years old Scotch and Weymouth Pines, which is the best mixture on such a soil, one Weymouth Pine being planted to three Scotch Pines.

The cost of planting in that case would be as follows:—

Digging by contract 2,720 pits per acre at 2s. 6d. per 100	£3	8	0
Planting 3,000 plants, allowing for refilling vacancies in the second year by daily labour	1	0	0
Cost of plants at 20s. per mille... ...	3	0	0
Total cost per acre	£7	8	0

Wherever there is no superficial pan, strong two years' old seedlings of Scotch Pine and four years' old Weymouth Pines should be used, but 4,000 plants per acre should be planted and the Weymouth Pines (1,000 per acre) planted in the second year. The cost then is considerably reduced, as the plants may be notched in without any preliminary digging of the pits, Dr. Schlich's notching spade, sold by Black & Sons, Berwick-on-Tweed, being probably the best implement for the purpose. Here planting should cost only 6s. per 1,000, while the cost of the Scotch Pines would be 4s. per 1,000, and that of the Weymouth Pines 20s. per 1,000.

The cost per acre should then be as follows, allowing 10 per cent for refilling failures.

3,400 Scotch pine seedlings at 4s. per mile	£0	13	7
1,000 Weymouth pine seedling transplants at 20s. per mile	1	0	0
Planting 4,400 plants at 6s. per mile ...	1	6	5
Total	£3	0	0

The woodman should always assist at the planting operations so as to ensure that the roots are given a natural position and the soil well trodden round the plants.

In both cases wherever better and deeper soil exists, Douglas fir and larch or Spanish chestnut should be planted instead of Scotch pine, but with a mixture of Weymouth pine, and this should not increase the cost to any appreciable

extent, provided the plants come from a home nursery. In the first case, there would be a saving in pitting expenses, as no pan exists on the better soil, where these species would be planted.

I have not made any estimate for nursery expenses, and if the plantation is to be at once started, this must be done with purchased plants, but it is much more economical to raise the plants in a home nursery, and such plants would also be superior to purchased plants if the woodman knows his business, while the risks of long journeys by rail are avoided. In case four years' old plants are used, 160,000 plants should be raised annually to allow for failures, and the nursery should be large enough to hold 320,000 transplants, as well as for the necessary seed-beds, paths, &c., so that about two acres of land are required; this should be strongly fenced, and a well sunk for watering the yearling seed-beds. For the first two years, 160,000 two years' old plants should be purchased and lined out, and about 30 lbs. of seed should be purchased, sown in prepared seed-beds four feet wide, every spring, and the plants lined out when two years old, nine by three inches, during the non-growing season. If chiefly two years' old seedlings are used, and larch will come under the category, the seed should be less closely sown, half a pound of seed to 120 square feet of bed, and only the Weymouth pines and Douglas fir lined out, so that a smaller nursery may suffice. It is, however, as well to have plenty of nursery ground, and the land not under plants can always be made to produce potatoes. This is not however the place to give a full account of nursery management, for which a reference may be made to standard books on Sylviculture. I shall not enter any charge for the cost of the nursery, as experience shows that it will be fully covered by the value of the planting material, which is included in the cost of planting already estimated. The cost of establishing a new nursery will not be covered in the first few years, but as planting is to be continued for twenty years, the original cost will be gradually repaid.

Plantations in succeeding years will follow on the plan already laid down, until the whole area of 1,000 acres is planted.

5. Tending the Plantations.

In the second year the woodman should go carefully over the preceding year's plantation and tread in any plants which may have been blown crooked by wind, and replace failures with fresh plants, using the larger transplants for the purpose. He will then also plant out the Weymouth pine in the vacant places left in the second class of plantation. He should also remove any birch plants or other weeds which

are interfering with the plants, though this may not be necessary till the third or fourth year after planting.

This second operation of removing any weeds should be seen to from time to time, and the woodman should also be on the look-out for attacks on the plants by *Retinia resinella*, a moth, the larvæ of which bores into the leading shoots of pines, and remove the galls it forms and burn them. Attacks by other insects are not generally to be feared in Britain, except on land which has been stocked with conifers, but should any such case occur, the proper remedial measures should be adopted. In the nursery, depredations by birds and damage by wireworms and cockchafer grubs may occur, and should be properly dealt with. The presence of any destructive fungi should also be at once noted and due precautions taken.

When the plantations are from 12 to 15 years old, a thinning may be required, although in France, the first thinning is generally deferred till the plants are 20 years old, when the produce of thinnings become saleable. Creosoted pine stems six inches in girth at the base make excellent stakes for fences, and the thinner material may be sold for bean-sticks, fuel, or other purposes, and should certainly repay the cost of felling, provided the thinning is not made too soon Only suppressed, crooked, and diseased stems should be cut as the object should be to grow the pines straight and free from knots. If close growth is encouraged, the pines will lose their lower branches naturally, but a certain amount of pruning of dead branches may be required. This thinning should generally be deferred till the wood is 20 years old.

(*b*) PEAT-BOG AND FENLAND.

Peat-bog is frequently valuable for fuel and other purposes, such as litter for stables, and in such cases planting is not advisable, but where the value of the peat is small, and a especially where most of it has been already utilised, plantations should be made. It is better to leave only one and half feet of peat, so that the plants may reach the mineral soil below, and the peat should be thoroughly drained before planting is commenced. Weymouth Pine grows well on German peats, and also Scotch Pine and Spruce, and I have seen good Douglas Fir growing on an English peat-bog. Oak may also be grown. It is difficult to give an estimate of the cost of drainage and cutting away superfluous peat, but the plants would be notched in, and this would not cost more than £3 per acre, the work proceeding as in (*a*).

In English fen-land, Tree-willows, Poplars, and Alders grow best, and may be planted, the two former as cuttings, and the Alders as nursery transplants. The poplar cuttings, with terminal shoots, are best raised in nurseries, where they should remain for four years, and the cuttings should be cut

from nursery plants before the plants have begun to sprout in the spring. The cuttings should be then kept with their bases in water till about the middle of April, when they should be planted 2 to 2½ feet deep with an iron dibble, somewhat smaller in diameter than the cutting, all branches should be pruned from the cutting, so that the wind will not affect its position. They should be planted 12 feet apart, and Alders planted 6 feet apart between them to form an underwood. Such Poplar transplants have terminal shoots, but when Tree-willows are planted, truncated cuttings are better, and should be cut back two years after planting, and only one of the shoots which spring from them kept to form a tree. With Tree-willows, Alder underwood is not required, but a pure crop should be raised. As already stated, the Poplars and Willows become ready for felling in about 25 to 30 years. I have no statistics as regards the cost of these plantations in England, but in France, one man can plant 250 Poplars in a day, so that the cost of planting should not exceed the following:—

Planting 300 Poplars	£0	4	0
Planting 300 Alders	0	6	0
Price of 300 Poplars in France at £2 per 100	6	0	0
Price of 300 Alders in France at 13s. per 1,000	0	4	0
	6	14	0
Refilling failures at 10 per cent ...	0	12	0
Total cost per acre	£7	6	0

Where Tree Willows are planted, the cost would be much less, as Willow cuttings are readily obtained from pollard willows, which are extensively grown in Fenland. The above is a rough estimate.

Cost of 300 Willow cuttings	£2	0	0
Planting do. do.	0	4	0
Cutting back in second year	0	4	0
Refilling failures	0	5	0
Total cost per acre	£2	13	0

Tree-willows should be planted in the same way as Poplars, but with truncated cuttings, about as thick as a broomstick. These should be cut back after two years when they are well rooted, and only one of the resulting coppice shoots be allowed to grow up into a maiden Willow. Where Pollard Willows are allowed to grow up, this cutting back is not required.

Osier beds are planted with terminal shoots, Osier cuttings being merely selected Osier wands, which are cut in January, and are planted immediately after the cutting at distances 2 feet by 2 feet, with an iron dibble. The cost of starting a new Osier bed is about £20 per acre, as much weeding must be done in the spring. The Osier bed is not fully productive till about the fifth year after planting. The yield is about 200 bolts per acre annually, worth, say, £20, a bolt of Osier wands being about 40 inches in girth and as much as a man can lift. In England the common Osier. *Salix viminalis*, is generally grown, as it yields a larger quantity of coarse material for hampers, fishtraps, wicker chairs, &c. Finer Osiers such as *Salix purpurea* (Spanish Osier) are used for basket-work.

(*c*) CLAY LAND, OR LOAM.

There is much clay land or loam in England, which has gone out of cultivation, and where plantations would be valuable and it will produce Oak, Ash, Spruce, Douglas Fir, or Silver Fir. At present Hazel, Alder, and Ash mixed coppice with Oak and Ash standards is the usual woodland on such soils, especially in the South of England, and provided the underwood can be readily sold this system gives good returns.

Supposing that 500 acres of such land are available for planting, and it is decided to grow trees in coppice-with-standards, a map should be made showing the proposed lining out of roads and rides, which are an important part of this system. There is no necessity for the roads being ready for the next twenty years, but their position should be marked out on the land as the planting operations proceed. One or two roads, 20 feet wide, which will eventually be metalled, should run through the centre of the block and communicate with the local road system. From these roads, the total length of which would not probably exceed two miles in length, rides 10 feet wide should run at right angles to the roads, so as to subdivide the block into 25 compartments, each of 20 acres. The compartments should as far as possible be oblong in shape, with their longest sides at right angles to one of the roads, as the produce from each compartment cannot pass through neighbouring compartments, but must come directly out on to a road. A sufficient length of road should be ready for traffic by the time that each compartment is felled.

It would take 25 years to plant the area, as it is best to adopt a rotation of 25 years, so that the underwood may be tall and may free the standards from lower branches and cause them to grow with fairly long boles. Although Ash underwood may be most remunerative, it is often wise to form the underwood of Alder, as this is the best species for stocking new land of the class in question and Alder poles 25 years old

are frequently 50 feet high and 2½ feet in basal girth and thus yield good material for clog-making, pit-timber, gunpowder, and other purposes.

Along with the Alder, 300 plants of which 12 feet apart should be used per acre, 300 Oak and Ash and 600 Larch saplings should be planted at equal distances between the Alder plants, so that the plants are six feet apart. They should then be allowed to grow until the Alder threatens the standards, when the former should be cut back to the stool. The Alder will then form clumps of coppice shoots, growing under the standards and assisting them to clear their boles.

Alder plants, three years old and 4½ feet high, can be purchased in Normandy, including carriage, at 14s. per mille, and pedunculate Oak, Ash, and Larch, four years old, at £1 5s. per mille. I give French prices, as quotations from English nurseries are £4 per mille. In this case also, a home nursery should be at once provided to yield good and economical planting material.

The cost per acre will be as follows :—

300 Alder transplants at 14s. per mille...	£0	4	2
300 Oak and Ash transplants at 25s. per mille	0	7	6
600 Larch transplants at 25s. per mille...	0	15	0
Cost of digging 1,200 pits at £1 per mille	1	2	0
Planting 1,200 plants, at 6s per mille ...	0	7	2
Refilling vacancies	0	4	2
Total cost per acre ...	£3	0	0

The plants should be pitted to ensure good and rapid growth. As already stated, the tending of these woods will consist in cutting back the Alder as soon as it threatens the standards, and in pruning the latter carefully, so that that they may produce straight standards, with only one leader. When the plantation is 15 years old, it may be necessary to cut away such of the coppice shoots as endanger the standards, and the same operation may be undertaken when the plantation is 20 years old.

The remainder of the land should be cultivated annually with field crops, and well manured, especially with chalk, which breaks up the clay. The sale of the crops should at rate repay the cost of cultivation until the land has been stocked with trees. It will in this case take 25 years to stock the whole area, and once this has been effected, fellings of the underwood would be made in one compartment annually, and such of the Larch poles may also be felled which interfere with the Oak and the Ash.

Such a system of coppice-with-standards provides excel-

lent cover for pheasants, but rabbits must not be allowed to propagate or they will soon destroy the underwood. The standards will be allowed to grow up after each felling until they become overcrowded, when the worst of them will be felled, and eventually those that are mature; but at each felling of a standard, a sufficient number of saplings should be planted to replace it, say 20 saplings for a mature standard 75 or 100 years old, and proportionally less for younger standards.

In localities, where underwood is unsaleable, the land may be planted with Larch and Douglas Fir; Pacific Douglas Fir in the South of England and in Ireland, and Colorado Douglas Fir in the North, wherever the former suffers from the early frosts. Plants, four years old, should be pitted-in five feet apart. Douglas Fir transplants are expensive in England, but two-years' seedlings may readily be obtained from Normandy or Holstein at 10s. per mille. In this case, for the first two years only, should four-years'-old transplants be purchased, and a sufficient number of two-years'-old plants put out in nursery lines for the third and fourth year's planting, after which the home nursery should supply the proper number of these plants for each year's planting. The plants should be pitted-in, so as to ensure a rapid growth. Here 50 acres should be planted annually, as in (*a*).

The cost per acre will be as follows:—

	£	s.	d.
900 Larch, four years old, at £1 per mille	£0	18	0
900 Douglas Fir, four years old, at £1 5s. per mille	1	2	6
Digging 1,800 pits at £1 per mille ...	1	16	0
Planting 1,800 plants at 6s. per mille. ...	0	11	0
Refilling failures	0	7	6
	£4	15	0

This estimate is for plants grown in a home nursery, as for the first two years Douglas Fir plants may cost twice as much, so that the first two years planting may cost £7 16s. per acre.

The tending will be of the same nature as in (*a*). Should the Larch become diseased, infected plants should be cut out and their places filled with strong Beech transplants.

A cheaper way of dealing with this class of land would be to plant 1,200 Larch per acre, 6 feet by 6 feet, and as soon as the Larch is well established to sow Silver Fir seed in patches hoed up between the Larch. Silver Fir seed costs only 6d. a lb. in Germany, and five or six seeds should be sown in every patch in November and only slightly covered with humus. The Silver Fir plants will grow under the shelter of the Larch, and when the Larch is mature, a Silver Fir wood will result,

which can be regenerated naturally, under the selection system.

The cost per acre will be :—

1,200 Larch at £1 per mille	£1	4	0
20 lbs. of Silver Fir at 6d. a lb. ...	0	10	0
Carriage of ditto	0	5	0
Planting Larch	1	12	0
Sowing seed	0	6	0
	£3	17	0

In this case 50 acres should be dealt with annually, and the whole area of 500 acres would be stocked in 20 years. Any wet patches on the land should be stocked with 3 years Spruce notched in 4 feet by 4 feet, and the cost of these plantings would be per acre:

Tending as in first case.

2,700 Spruce plants, 4 years old, at 15s. per mille	£2	0	9
Planting at £1 per miile	2	14	0
Refilling vacancies	0	8	3
Total per acre	£5	3	0

These plantations would require very little tending for the first 20 years, as the thicker the Silver Fir and Spruce grows, the better will be the future of the trees.

(*d*) Inferior Pasture Land.

If land of this class is loamy, it may be treated in the same way as (*c*), but if it is sandy, it may be treated like the better class of land in (*a*).

(*e*) Land on Hill-sides, that is very Stony, or Covered with Boulders.

Here, provided the soil is deep enough, most of our better trees will thrive, but the degree of moisture in the soil will vary according to the aspect. Aspects facing south or west are comparatively dry, whilst northerly or easterly aspects are moist.

On the warmer aspects Larch frequently fails, and a mixture of Corsican Pines, Sessile Oak, and Beech, 4 feet by 4 feet, would thrive.

On the cooler aspects Larch and Beech should be planted, 6 feet by 6 feet, as in (*c*), and sown up with patches of Silver Fir seed, the object being to obtain a Beech and Silver Fir wood after the Larch has been cut out.

The cost per acre in the former case would be about £5 per acre, the plants being pitted in. Great care should be taken to obtain acorns of Sessile Oak, which are abundant in Wales. The tending would be chiefly directed to protecting the Oak from the Pines and the Beech, and the former should be cut out and the Beech cut back, whenever they interfere with the Oak plants. The latter should be carefully pruned, whenever this is required.

In the latter case the cost would be £4 7s. per acre, and little or no tending would be required for the first 20 years, as Beech and Silver Fir do not suffer from the shade of the Larch. Any diseased Larch should, however, be cut out.

(*f*) Land on Chalk or Limestone Hills.

Here we must also distinguish between hot and cold aspects. On the latter the soil will generally be deeper and moister, and planting much easier than in the former case,

On hot aspects above limestone rock, it is difficult to get trees to grow at first, but when once a crop has been produced and the soil enriched with dead needles or leaves, the growth of trees is easier to secure.

The Black Pine is often the only tree that will at first grow in such places, and this should be pitted in, 4 feet by 4 feet, with Beech wherever the soil is deeper than a foot. This will cost £5 per acre.

Little tending will be required for twenty years, as the object should be to get the area covered with a dense wood to enrich the soil.

On cool aspects, Beech, with a mixture of Sycamore and Sessile Oak wherever the soil is deep enough for these species, should be planted under a shelter-wood of Larch, which should be planted, 12 feet by 12 feet, the hardwoods filling up the intervals to 4 feet by 4 feet. Pitting should be adopted. The cost will be about £5 per acre.

Or Silver Fir seed may be sown under the Larch as in (*c*).

Tending will consist in protecting the Oak from the Beech and Sycamore, and the wood otherwise should be allowed to grow up unthinned for twenty years.

Having now sketched the mode of treatment of the different classes of land available for planting, I will proceed to discuss the future of the plantations after they are 20 years old and the probable financial results.

VI.—TENDING OF THE WOODS AFTER THEY ARE TWENTY YEARS OLD AND PROBABLE FINANCIAL RESULTS.

The plantations already described, except in the case of osier beds already discussed, and Poplars and Willows which

become mature in about thirty years, and are usually confined to small areas, and coppice-with-standards, where regular fellings of the underwood will commence in the 26th year, will not become mature for a more or less prolonged period, and provided more land is available, it is advisable to continue the planting operations until the period of maturity is reached; when the oldest crop is eighty years old the whole area of woodland should eventually form a working-section of 4,000 acres, in which all ages up to a mature crop eighty years old are represented. Eighty years is probably sufficient, at any rate during the first rotation, to produce good saleable timber, at the rate of growth in Britain of all the species mentioned except Oak. When this working section is completely stocked, the question of prolonging the rotation, if necessary, may be considered, but will not be further discussed here.

If smaller working-sections are considered advisable, proportionately smaller areas should be planted annually, but I have considered the subject from the point of view of the formation of important woods, which will give full employment to an energetic and capable forester, assisted by good expert advice. The woodlands belonging to the Earl of Yarborough in Lincolnshire, which, as far as I know, are the only ones in Britain that form complete working-sections of high forest, comprise 5,000 acres with 100 years rotation, so that 50 acres are cut and restocked annually.

The question of road-making must be considered, and it will probably be necessary to have eventually 12 miles of roads for the 4,000 acres. Gravel will probably be available on the site, and rough macadamised roads should not cost more than £750 per mile, but the presence of good roads vastly increases the price obtained for timber, and arrangements should be made from the 30th year to have roads ready for the export of the material from thinnings, and three or four years before the final felling commences in the 81st year, in order to remove the heavy material coming from final fellings on twenty acres per annum. £9,000 may eventually be required for these roads, or £150 a year for 60 years.

(*a*) Plantations on Sandy Heather Land.

In the 21st year, a thinning should be made in the Pine woods, so as to remove all suppressed, diseased, crooked or dead stems. This first thinning will probably pay for its expenses only by the sale of the produce, but subsequent thinning made every ten years will, according to Dr. Schlich, produce the following volume of timber (quarter-girth measurement) and receipts per acre.

Age of Wood.	Yield in cubic feet per acre.	Price per cubic foot.	Value per acre.	Yield for 50 acres.	Value for 50 acres.
					£
30	40	3d.	10s.	2,000	25
40	150	4d.	50s.	7,500	125
50	330	5d.	137s.	16,500	342
60	380	6d.	190s.	19,000	475
70	400	7d.	233s.	20,000	582
	Total yield of thinnings		... ...	65,000	£1,543

REMARKS.—£25 a year will be continued till the 80th year, and during the second and further rotations. The same applies to each of the figures in the last column after the first year of the respective thinnings.

During the first rotation, the present values of the thinnings till the eightieth year, are at 2½ per cent,

£						£
25	×	28·36	×	·477	=	338
125	×	25·1	×	·372	=	1,167
342	×	20·93	×	·291	=	2,083
475	×	15·59	×	·227	=	1,681
582	×	8·75	×	·178	=	906
Total present value of thinnings						£6,175

This amount, capitalised for 80 years with interest at 2½ per cent., will amount to

£6,175 × 7·21 = £44,522

which is the prospective value of the thinnings in the 80th year of the rotation. Now the cost of planting has been estimated at £7 8s. per acre, the annual expenditure will therefore be as follows:—

Planting Expenses	£370	0	0
Woodman's Pay	79	0	0
Incidental Expenses (Rates, House Rent, Repairs to Roads, Ditches and Fences, &c.	155	0	0
Total Annual Expenses	£600	0	0

This annual payment if capitalised for 80 years, at 2½ per cent., will amount to £600 × 34, 45 × 7·21 = £149,031.

As already stated, £8,000 is to be expended on roads, this expenditure commencing in the 31st year, and continued at £150 per annum until the 80th year.

The present value of this expenditure is

$$£150 \times 31 \times \cdot 477 = £2,218$$

and this amount capitalised at $2\frac{1}{2}$ per cent. for 80 years will amount to £2,218 × 7.21 = £15,992.

The capital expenditure therefore, exclusive of the value of the land and deducting the capitalised value of the thinnings, will by the 80th year amount to

$$£149,031 + £15,992 - £44,592 = £120,431.$$

As regards the cost of the land, it should not be more than £8 per acre for the land of the class dealt with, corresponding to a rental, at $2\frac{1}{2}$ per cent., of 4s. per acre. The land will be planted gradually, and what is left unplanted will presumably produce its full rent.

Now £8 × 4,000 = £32,000 is the value of the land, which, capitalised for 80 years, at

$$2\tfrac{1}{2} \text{ per cent.} = £32,000 \times 7\cdot 21 = £220,720.$$

But as the land is only gradually planted, half this amount will be recovered in rent during the planting period. Matters might become even more favourable were the planted land leased for shooting pheasants, but in this case it is probable that fencing would be required, so that no estimate will be made for receipts from a sporting lease.

The cost of the land is therefore put at £110,360, and the whole capital involved is

$$£110,360 + £120,431 = £230,791, \text{ or say } £231,000.$$

The mature wood 80 years old will produce per acre in principal fellings 4,300 cubic feet (quarter-girth measurement) worth 8d. a cubic foot, or £143 per acre, £143 × 50 = £7,150 for the 50 acres cut annually. The value of the thinnings is £1,549, so that the gross annual revenue from wood will be

$$£7,150 + £1,549 = £8,699 \text{ or say } £8,700.$$

The yield in material is as follows:—

	CUBIC FEET.
Principal Fellings, 4,300 × 50,	215,000
Thinnings	65,000
Total yield ...	280,000

being 70 cubic feet per acre per annum. The volume of the standing crop on the 4,000 acres will be 11,200,000 cubic feet, and its value about £70 per acre, or £280,000.

A fully stocked wood of 4,000 acres has now been produced, and this should certainly yield 4s. an acre for game, which would cover the rental value of the land, while there are always other items of revenue from sale of bracken, &c.,

which, however, need not be taken into account here. Expenditure on maintenance of the wood will necessarily be increased, now that extensive fellings are carried out annually, and an experienced well-educated forester should be engaged on £250 a year, with two woodmen on £75 and £50, and these three men should be properly housed. The head forester will also keep the accounts, unless it is thought advisable to engage a clerk for the purpose. If the wood is clear-cut, planting will be continued over 50 acres annually, but the planting must then be delayed for three years after the felling, to prevent attacks by the pine-weevil. The plantations would henceforth cost only £3 per acre, as the pan has been broken through and the surface soil enriched and deepened by the decaying needles and twigs, which have fallen from the trees for 80 years.

The following is our estimate of the probable current annual expenditure after 80 years.

Head Forester	£250
First Woodman	75
Second Woodman	60
House rent for staff	60
Planting expenses	150
Rates	300
Incidental expenses, including repairs to roads, buildings, fences, and ditches	105
	£1,000

The planting expenses would be saved for the first three years, but the amount saved, £450, should be spent on roads. About £600 would be spent at once on building, but interest on this, £60, is allowed for in house-rent, so that this sum would be gradually recovered.

Thus the gross revenue being £8,700, a net annual revenue of £7,700 would be obtained, being about three per cent. on the capital expenditure of £231,000, or £1 18s. per acre annually, while the new capital value, estimated at 2½ per cent. interest, of the wood and land, allowing for the necessary expenditure is £308,000, showing a gain of capital of £77,000.

Supposing that the cheaper form of planting at £3 per acre were adopted from the first, planting expenses would be greatly reduced, while the timber yield would be better, as the soil is presumably of better quality, A higher price, however, would be paid for the land, say £12 per acre. If we allow 10 per cent. increase in the yield of thinnings, these would in 80 years amount to £44,500 + £4,450 = £49,000 in round numbers.

The capitalised value of the land in round numbers

would be $\frac{3}{2}$ × £220,720 = £331,080, only half of which, or £165,500, would be actually invested.

The expenditure from the first would be as follows :—

Planting expenses	£150
Woodman's pay	75
Incidental charges	175
	£400

The capitalised cost of planting would therefore be :—

$\frac{2}{3}$ × £149,031 = ...	£99,354
From which deduct for thinnings ...	49,000
Leaving	£50,354
To which is to be added for roads ...	15,992
and	£66,346

is the total capitalised expenditure.

Adding to this the capitalised value of the land, we have £165,500 + £66,346 = £231,846, or in round numbers £232,000, as the total capital.

We may allow 10 per cent. increase in the yield of fellings due to the better soil, so that the volume of timber from the principal fellings would be :—

4,300 + 4, 30 cubic feet per acre	
4,730 cubic feet × 50 =	236,500 cubic feet
Thinnings	71,500 do.

And the total annual yield is 308,000 cubic feet

or 77 cubic feet per acre annually. The gross income received from fellings would be as follows :—

Principal fellings	£7,883
Thinnings	1,604
Total ...	£9,487

from which £1,000 expended annually must be deducted, leaving a net revenue of £8,487 being about $3\frac{3}{5}$ per cent. on the capital of £232,000.

The new capital value of the property would stand at £339,480, showing a gain of £107,480, in the first 80 years.

In either case natural regeneration might now be adopted instead of planting, but the consequent saving in cost would not be great, and in the Pines, replanting is generally found to answer better than natural regeneration.

It would make this essay too long were I to discuss the financial prospects of each class of woodland that I have described, and the above may be taken as a type of the different cases of high forest, as it is easily seen that the price paid for the land is the chief factor to be considered, although economy in planting expenses is also very important. As I have already stated, Silver Fir, and Douglas Fir with Larch, will give the best financial returns, and these woods and Beech woods might be regenerated naturally under the Selection system, which would cost little for management, when once the wood is constituted.

The case of coppice-with-standards, however, differs considerably from the above, especially as the wood is constituted in 25 years only. I will therefore terminate the essay with an account of the management and financial prospects of this method.

(*b*) Coppice-with-Standards on Clay Land.

In the 26th year, when the 500 acres are fully stocked, the first regular felling of the underwood should be made, although, as already stated, clearings of the coppice will have been carried out in order to protect the young standard trees from being suppressed or injured by the underwood. One compartment of 20 acres should be dealt with annually and all the underwood cut close to the stool. At the same time, half the number of Larch poles should be felled and the standards carefully pruned, wherever this is necessary. Three hundred Oak and Ash standards should be planted to replace the felled Larch, and to introduce a succession of ages into the overwood, where eventually there should be standards of every age from saplings to mature trees, each of which should have its crown free from those of its neighbours, so that each tree can develop rapidly.

As mentioned before about two miles of metalled roadway must be prepared, but this need not be commenced till about the 20th year of the rotation, after which steady progress in roadmaking should continue until the entire length has been completed. At £1,000 per mile, for heavy clay land is in question, these roads will cost £2,000, and their importance may be gauged from the fact that often twice as much is paid for timber and underwood where the roads are good than where transport from the forest is difficult. The expenditure on the roads may, however, be carried over 25 years at £80 a year.

The present worth of this expenditure, which is estimated to begin in the 20th year, is £80 × 18.42 × .61 = £900 in round numbers, and the capitalised value of this by the 25th year at 2½ per cent. is £900 × 1.85 = £1,665.

The value of the land here may be estimated at £10 per

acre, or £5,000, half of which will be chargeable to capital account, the rental value of the remainder as well as the rates, being recovered during the first 25 years by the continuance of agriculture till the land is planted and by the lease of the wooded area for pheasant shooting.

The cleanings made during the first 25 years will barely repay the cost of making them, as they yield only small material for stakes, bean-sticks, or firewood.

The cost of planting is £3 per acre, and as 20 acres are planted annually, this amounts to	£60
Pay of woodman	60
Incidental expenses, chiefly laying out roads and rides, and rent of woodman's cottage ...	30
Total expenses during the first 25 years ...	£150

This amount capitalised for 25 years at 2½ per cent. will be

£150 × 18.424 × 1.854 = £5,124

The capitalised value of half the land will be

£2,500 × 18.54 = £4,635

so that capital outlay by the 25th year will be

Planting expenses	£5,124
Road-making	1,665
Capitalised value of land	4,635
Total Capital	£11,424

or in round numbers, £11,500.

The yield from the coppiced Alder will be £10 per acre, or £200 for 20 acres, and the 300 Larch poles will sell at 1s. each, or £15 per acre, £300 for a compartment. The coppice wood now forms a fine cover for pheasants, and would let for £150 a year, so that the gross annual revenue will be £650.

The expenditure from the 26th to the 30th year will be as follows :—

Planting 300 Oak and Ash at 15s. per acre ...	£15
Pay of woodman	60
Contingencies, chiefly repairs and house rent ...	75
Rates	100
	£250

leaving a net annual revenue of £400, or 3½ per cent. on the capital outlay.

In the 51st year, the remaining 300 Larch standards, now worth 4s. each, will be felled, producing £60 per acre, while some of the worst Oak and Ash standards may also be felled, giving about £5 per acre. This, including £10 for the Coppice, is £75 per acre, or £1,500 for a compartment, and with £150 for the sporting rent, the gross revenue will be £1,550

It will now be necessary to raise the salary of the woodman to £100 and 600 Oak and Ash standards per acre should be planted annually so that annual expenses will be as follows :—

Planting	£30
Woodman	100
Rates	100
Contingencies	120
	350

leaving a net annual revenue of £1,350.

When the wood is 75 years old, in the 76th year, about 600 cubic feet (quarter-girth measurement) of Oak and Ash standards may be felled annually besides the Coppice. The standards should sell at 2s. 6d. per cubic foot, or at £75 per acre, and this with £10 for the underwood amounts to £85 × 20 = £1,700, which together with £150 for the sporting rental gives a gross revenue of £1,850 and the annual expenses continuing as before, we have a steady net revenue of £1,550 for 500 acres of land, or over £3 per acre.

It may objected that this is higher that the yield of any existing coppice-with-standards, but I have never seen any area under this treatment in Britain which would not be immensely benefited by proper management, while the prices of Oak and Ash wood must increase, as the supply from abroad falls off, which appears inevitable.

In both the cases dealt with, the timber and underwood are supposed to be sold standing, and the prices given and yield of timber estimated are taken from woods known to the writer.

(*c*) CONCLUDING REMARKS.

An important consideration is that when a Company, Corporation, or Municipality plants, death duties will not from time to time impose heavy charges on the capital value of the wood. Another point which has already been urged on Government, is that the remission of half rates on land that is planted, but when the trees are too young to yield a full return, appears to be even more justifiable than in the case of lands under agriculture which already pay only half rates.

Great importance is here attached to the formation of good metalled roads for the removal of material, as without these, merchants will offer only small prices for timber, and the profitable nature of expenditure on means of transport has been proved over and over again both in Britain and on the Continent. In hill districts other modes of transport, such as tramways, slides, wire-tramways, sledge-roads, or cart-roads, may be required. In order to make plantations finan-

cially successful it is highly important to spend less in the early years of the plantation, where it gives no returns, and to defer heavy expenditure till a later period.

All expenditure has to be capitalised at compound interest until the wood is mature, and obviously money expended judiciously when the wood is nearly or quite mature figures much less at compound interest than even smaller sums expended early in the life of a Plantation.

W. R. FISHER.

COOPER'S HILL
ENGLEFIELD GREEN,
December 30*th*, 1903.

3 2044 102 825 098